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CANCER AND OLD AGE

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THE cancer problem looms large in any consideration of the public health aspects of old age. The problem merits emphasis at present, because, on the one hand, cancer is a disease predominantly (though not exclusively) of old age, and on the other, the proportion of old people within the total population is increasing annually and progressively.

It is hardly necessary to point out at the beginning of this discussion that there are wide gaps in our knowledge of cancer; that fundamental causes of malignant growths are unknown or at least imperfectly understood; and that hence, a consideration of such a topic as the relationship between cancer and old age must take into account these gaps and deficiencies in our knowledge.

On the other hand, there is a substantial body of factual data which has been developed in relatively recent years (coming from such diverse fields as biology, biochemistry, biophysics, epidemiology and clinical medicine) from which there is emerging a general philosophy of cancer even though certain fundamental details of the picture remain, as yet, obscure.

Perhaps one of the most significant single components of the modern philosophy of cancer is the concept of the multiple character of the disease.

For many years cancer research was concerned largely and quite appropriately with such expressions of the disease as were found to be commonly associated with cancer of all anatomical sites. During the latter part of the nineteenth century, for example, cancer research was devoted almost exclusively to detailed study of the morphology of tumors, classification of cancer into separate histologic varieties, and the description of features generally applicable to all of its clinical and histologic forms. This contributed to the establishment of certain "criteria" of malignancy such as capacity for unrestrained growth, invasiveness and metastasis.

In the tumor research of more recent years, emphasis has shifted to more specific considerations of etiology. With the extension of knowledge thus acquired and with increasing consideration of the disease from the point of view of its broader—more especially its mass—manifestations, cancer is becoming differentiated into increasing numbers of separate entities. Thus present students of the problem have come to regard the diversity with which this large group of conditions we speak of as cancer expresses itself as being equally as striking and significant as the few characteristics generally regarded as common to it.

Even in these common characteristics, cancer of different anatomical sites and

histologic types shows striking variations. Various cancers or malignant tumors show remarkable differences in their functional capacities, their invasive qualities, the rapidity with which they grow, spread, and metastasize and their vulnerability to such physical agents as x-rays and radium. Considered from the point of view of its epidemiology, of various extraneous and environmental factors contributing to its etiology, of its geographical, racial, sex and age distribution, cancer presents a picture, not of a single entity, but of a group of more or less related conditions, the number of which is scarcely limited except by the number of organs and tissues which it attacks.

Thus, for a more thorough understanding of the relationship between cancer and old age, it will be necessary ultimately to consider each anatomical site of cancer separately, especially as regards its age distribution and also the variety of factors contributing to its etiology.

For an insight into the age distribution of cancer, excellent data are now available, some of the most extensive of which are in the records collected during recent years by the U. S. Public Health Service as a part of the general program of investigations of the National Cancer Institute. During the past two years surveys of cancer incidence have been made by the Public Health Service, covering the adjacent counties and cities of Philadelphia, Pittsburgh, Detroit, Chicago, Atlanta, Birmingham, New Orleans, Dallas, Fort Worth, Denver, and the San Francisco Bay region. In these surveys records have been obtained which show the age, sex, color, residence and primary site of disease of all cancer patients who came under the observation of the reporting physicians, clinics and hospitals within the communities, during the one-year period immediately preceding the survey.[1] For purposes of showing the age distribution of patients, the data which have been analyzed for all the communities except New Orleans, Philadelphia, Birmingham and Denver are available. These data cover the records of a total of 38,544 persons and relate to malignant tumors of every histologic type and anatomical site. The two accompanying tables are included for purposes of brief summary.

TABLE 1

THE AGE DISTRIBUTION OF PERSONS WITH CANCER (ALL FORMS) REPORTED FROM SELECTED COMMUNITIES IN THE UNITED STATES, 1939

Age of persons	Cases of cancer—all forms	
	Number	Per cent. of total
0–9	182	0.5
10–19	299	0.8
20–29	892	2.3
30–39	3016	7.8
40–49	7794	20.0
50–59	9935	25.7
60–69	9651	25.0
70–79	5474	14.2
80–89	1213	3.1
90+	88	0.2
Total	38,544	99.6

Table 1 shows the age distribution of the thirty-eight and one-half thousand persons reported as having malignant tumor and including persons of both sexes and all races. It will be noted that almost exactly half of the total persons fall within the age group 50–69 years. A fifth of the patients are in the group 40–49 years, and an almost equal number at ages over 70. It is of some special interest to note that one out of ten of these patients is under 40 years of age. The data in this table merely confirm the results of repeated observations elsewhere, namely, that the bulk of cancer is found in late adult life and old age.

However, it should be emphasized that

[1] As evidence of the cooperative spirit of the medical groups in these communities, it should be noted here that all of the clinics and hospitals, and more than 95 per cent. of the practicing physicians made returns in these surveys.

these data show only the over-all picture of cancer and do not portray the differences which actually exist as between the two sexes, different races and different anatomical sites of the disease. While a more detailed consideration of the subject would necessarily take all of these factors into account, it is believed that for present purposes the data in Table 2 will suffice. This table shows the distribution in broad age-groups of persons with cancer of certain selected anatomical sites. The second column of the table shows the number of persons with cancer of the various sites merely to indicate the statistical reliability of the percentage figures. The data refer to the principal (but by no means all) sites of cancer. The sites, as listed, are arranged in the order of their relative frequency in persons under 30 years of age. Except for skin, lip and rectum, the order of arrangement in the column "Under 30" is almost the reciprocal of that in the column "70 and over."

TABLE 2

THE AGE DISTRIBUTION OF PERSONS WITH CANCER OF CERTAIN ANATOMICAL SITES

Primary site of cancer	Cases of cancer of selected sites					
	Total number	Percentage in persons at ages				
		Under 30	30–49	50–69	70 and over	Total
Bone	594	26.9	29.7	37.4	6.0	100.0
Uterus	5818	2.7	41.2	48.3	7.8	100.0
Skin	5101	2.6	20.4	49.8	27.2	100.0
Lip	1364	2.2	30.0	51.1	16.7	100.0
Rectum	2107	2.2	24.0	56.2	17.6	100.0
Lung	939	1.8	30.4	57.7	10.1	100.0
Breast (female)	5980	1.6	36.6	49.9	11.9	100.0
Larynx	471	1.2	21.9	64.0	12.9	100.0
Stomach	3014	0.8	19.2	57.8	22.2	100.0
Bladder	1265	0.6	17.8	55.8	25.8	100.0
Prostate	1432	0.2	3.4	50.1	46.3	100.0

As compared with cancer of all sites, malignant tumors of the bone and the uterus show an excessive prevalence in relatively young persons; cancer of the lip, rectum, lung, larynx and female breast tends to be concentrated in the third to sixth decades; cancer of the stomach, bladder and prostate occur with much greater frequency after the fifth decade (showing very high frequencies at ages 70 and over); and cancer of the skin is somewhat more evenly distributed throughout the life-span (ranking third in relative frequency at ages under 30, and second at ages 70 and over).

From the data presented above, it is clear that cancer is a disease predominantly of late adult life, but by no means exclusively so. Thus one may postulate a correspondingly predominant, but by no means exclusive, role for the aging processes of the tissues of the host as a contributing factor in the genesis of cancer.

Most students of the disease view the etiology of cancer as coming within two more or less broad categories: (1) Extraneous and environmental factors, most of which are endowed with properties for producing chronic irritation; and (2) factors inherent in the human host.

Extraneous factors surrounding the development of the disease are believed to be variously combined for practically all malignant tumors. Certain combinations of these factors are already known to be quite distinctive for various cancers. The best examples of distinct etiologic agents are found in occupational cancer such as skin cancer in oil and paraffin workers, skin cancer of sailors and farmers who have undergone many years of excessive exposure to sunlight, x-ray cancer, cancer of the bladder in persons engaged in the handling of anilin dyes, scrotal cancer in chimney-sweeps, and cancer of the lung in cigar-makers, weavers, and those employed in certain mine operations.

Other examples of commonly associated extraneous factors with cancer genesis are to be found in the lip cancer of pipe smokers, the Kangri and betel-nut cancers of certain tribes in India, cancer of the tongue in persons with

irregular jagged teeth, skin cancer superimposed upon the sites of ulcers, burns, chronic sinusitis and with Paget's disease of the nipple. Certain cancers, particularly of the bone and testicle, appear frequently to have a traumatic origin.

In connection with the above, it may be pertinent to mention the extraordinary fact of the extreme rarity of cancer of the penis among persons circumcised during infancy, in contrast to its relative frequency among the uncircumcised. Of special interest is the observation that the disease is almost never encountered among Jews who are circumcised during infancy, but is relatively common among Mohammedans, for example, among whom circumcision is almost universal, but at a later age, usually around puberty. This phenomenon conceivably might be explained on a basis of a racial immunity in the Jew, but such an explanation would require the postulate of a specific organ immunity in view of the frequency with which cancer of all other organs and tissues is found in the Jew.

In the light of existing knowledge, no concept of cancer genesis is reasonable which does not postulate some etiological significance to factors inherent in the human host. Certain malignant tumors may be ascribed reasonably to processes of chronic irritation acting upon normal cells. On the other hand, it is difficult to reconcile the peculiarities of development of many cancers with any point of view which does not assume the existence of local tissue predisposition; and there are still other tumors in which a constitutional predisposition toward their development appears to be of real significance.

The importance of these factors of host susceptibility and tissue predisposition is extremely difficult to measure. Such factors are too subtle and present methods of observation too crude to bring them into focus and permit a quantitative assessment. Some of them, suggested through clinical observations, tend to be confirmed in the experimental laboratory; others are merely suggested, and confirmation must await further studies in clinical, epidemiological and experimental fields.

Examples of predisposing factors are found in the assumption of cancer genesis from isolated embryonal cell groups, from the persistence of tissue which normally regresses after embryonal life, from developmental defects of organs and tissues, from conditions of imbalance of endocrine gland activity, especially as related to sex hormones, from conditions associated with overnutrition, from conditions regarded as hereditary or congenital, and finally from factors inherently associated with race, sex and age.

Just as it has been impossible to give relative values to the importance of the "seed and the soil" in human tuberculosis, so is it difficult to assess the relative significance of extraneous and "endogenous" factors in human cancer. This is especially so when the "aging process" is included as one of the "endogenous" factors for appraisal.

Most evidence at hand, especially that arising out of clinical experience, emphasizes the long interval between exposure to extraneous factors and onset of malignant tumor. This evidence is particularly notable in cases of occupational cancer where exposure to occupational hazard antedates by many years the onset of the disease. It is not unusual, for example, to find cancer of the bladder developing among dye workers more than a decade after such persons have discontinued their employment. If the immunity of the Jew to cancer of the penis may be ascribed to circumcision during infancy, and the fact accepted that circumcision at puberty affords no such protection for the Mohammedan, the

inference may be justified that whatever the cancer-exciting factor may be (as related to the absence of circumcision), it requires a long period of latency to express itself in clinical disease.

The necessity for taking into account this long interval of "incubation period" adds materially to the complexities of cancer research. For a better understanding of the peculiarities in the age distribution of cancer it will be necessary ultimately to resolve many questions, the answers to which are unknown at present: For example, is old-age cancer merely a function of long time action required by the exciting etiologic agent, or are there factors associated with the aging process itself which alter the tissues of the host so as to make them increasingly susceptible to malignant changes with advancing age? If the phenomenon is essentially a function of the aging process, how can one distinguish between physiological and chronological age? What are the physiologic characteristics of aging? And finally how can they be modified? An effort to resolve such fundamental questions as these is a challenge to modern cancer research.

We need to know more about the fundamental principles underlying growth itself; studies must be encouraged in clinical and epidemiological fields in an effort to define more specifically and measure more accurately the variety of extraneous factors contributing to the etiology of cancer. More information on the aging process itself should contribute in a remarkable way to a better understanding of the cancer problem.

Although much remains to be learned about the basic causes of cancer, and hence interpretations of such causes, in the light of existing gaps in knowledge, necessarily are, to a certain extent, speculative, the public health implications of the cancer problem in an aging population are none the less real or significant.

Most students of population, assuming a "conservative" immigration policy and reasonable mortality and fertility rates, estimate that the population of the United States will have reached a peak (somewhere near 160,000,000) during the next 40–50 years. They are agreed also that a change in the age distribution is a fundamental feature of these population trends. It is estimated that 40 years hence there will be approximately an equal number of persons (two million) at each year of age from birth to 60 years. Although there will be a smaller number of persons at later ages, these will form a much larger proportion of the total than at present. According to these estimates, 15 per cent. of the population in 1980 will be over 65 years of age as contrasted with a little more than 6 per cent. at present and only 4 per cent in 1900.

Thus there can be no serious question as to the significance of the future cancer load in the United States when it is realized that during the next 30–40 years the population of the country 55 years of age and over, who now contribute annually 5 deaths from cancer out of every 1000 living, or among whom 12 out of every 100 deaths from all causes are due to cancer, will have reached approximately 40 million.

On the basis of numbers alone, the potentialities of the cancer problem are enormous. However, any well considered plan for meeting the problem in the future must take into account the fact that an aging of the population not only increases the number of the aged, but also impinges in a variety of ways upon the economic, social and cultural patterns of the country. The urbanization of the population may well contribute factors both favorable and unfavorable to the cancer situation—unfavorable by

reason of environmental hazards contributing to cancer genesis—favorable by virtue of increased opportunities for the provision of facilities for clinical cancer service and research: The rapid tempo of social changes may likewise influence the problem through the accompanying complexities of living and artificiality of foods: The regional distribution of population density, the geographical distribution of industrial employment and technological progress in industry and agriculture may all be worthy of consideration in view of the known geography of cancer and the industrial origin of many of its forms. Finally, since the control of cancer depends largely upon facilities for diagnosis and treatment, the problem can not be divorced from broader considerations of general medical service and the way in which these considerations will find expression in a national health policy.

Public Health, like all other segments of public service, is profoundly concerned with the social and economic changes incident to the aging and growth of the population. This concern can be expressed most effectively by Public Health through an attempt to study and anticipate these changes, and, on the basis of experience and knowledge thus acquired, direct its own efforts in harmony with them and in whatever manner possible exert its influence toward guiding them in a constructive way.

As regards cancer, obviously the first challenge is to extend our frontiers of knowledge of the causes of the disease and of methods for its control; the second requirement, which is equally as challenging, calls for the application of such knowledge in the most effective way and through facilities, procedures, and methods of organization in harmony with the spirit of constructive public service.

THE DARWINIAN THEORY AND RELIGION

It would be impossible for any one to discuss in a fair and intelligent manner the great question of the origin of species, in anything less than a bulky volume. The merest mention is, therefore, all we can give to it at the present time. Although the appearance of Darwin's book on the "Origin of Species" communicated a distinct shock to the prevalent creeds, both religious and scientific, the hypothesis which it suggests, though now for the first time distinctly formularized, was by no means new; as it enters largely into the less clearly stated development theories of Oken, Lamarck, De Maillet, and the author of the "Vestiges of Creation." There was this difference, however, that in the developmental theories of the older writers the element of evolution had a place; the process of development had its mainspring in an inherent growth, or tendency, such as produces the evolution of the successive parts in plant-life, while, according to Darwin, the beautiful symmetry and adaptation which we see in nature is simply the form assumed by plastic matter in the mould of external circumstances.

Although this Darwinian hypothesis is looked upon by many as striking at the root of all vital faith, and is the *bête noire* of all those who deplore and condemn the materialistic tendency of modern science, still the purity of life of the author of the "Origin of Species," his enthusiastic devotion to the study of truth, the industry and acumen which have marked his researches, the candor and caution with which his suggestions have been made, all combine to render the obloquy and scorn with which they have been received in many quarters peculiarly unjust and in bad taste. It should also be said of Mr. Darwin that his views on the origin of species are not inconsistent with his own acceptance of the doctrine of Revelation; and that many of our best men of science look upon his theory as not incompatible with the religious faith which is the guide of their lives, and their hope for the future. To these men it seems presumption that any mere man should restrict the Deity in His manner of vitalizing and beautifying the earth. To them it is a proof of higher wisdom and greater power in the Creator that He should endow the vital principle with such potency that, pervaded by it, all the economy of nature, in both the animal and vegetable worlds, should be so nicely self-adjusting that, like a perfect machine from the hands of a master maker, it requires no constant tinkering to preserve the constancy and regularity of its movements.—*From an address by J. S. Newberry (1822–1892), delivered as retiring president of the American Association for the Advancement of Science at its annual meeting in Burlington, Vermont, in August, 1867.*

ERRORS IN SCIENTIFIC METHOD—GLACIAL GEOLOGY

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Early Explanations of the Drift

Wide-spread over northern North America and Europe lie the direct deposits of continental ice-sheets, the boulder-clay or till; and along with these the gravels and sands left by the waters which everywhere accompanied the melting of the ice. There was no correct understanding of this material, called "drift," until after Agassiz's work, or about 1840. In the absence of such an understanding, how did the early geologists explain the drift? They could not fail to notice it, especially the erratics, immense blocks often far from their original ledges and in positions hard to account for.

To understand the difficulty of the situation it is necessary to have certain facts in mind. We are living to-day in the closing stages of a glacial period. To be sure, the great ice-sheets of northern America and Europe are gone. But glaciers still occur in the mountains, even under the equator. The snow line gets lower and lower toward the poles, until we find valley glaciers entering the sea in Chili and southern Alaska. An ice-cap some 700,000 square miles in area covers Greenland, and the Antarctic ice-cap is estimated to have an area of over 5,000,000 square miles. Daly estimates the ratio of present ice to that of the maximum of the last or Wisconsin ice-sheet as one to three. Clearly we are not yet "out from under." Nor can anyone foretell the future. It would not be geologically unprecedented if the ice-sheet were to return, and, moving south from Canada to something like its former limit, wipe out all human construction in the populous area of northeastern United States.

We are living in an exceptional period, geologically speaking. Throughout most of the earth's past, glaciers were non-existent and mild climates extended well toward the poles. Suppose man had made his appearnce a bit later than he actually did, not during the last stage of the ice period but after its close, when the climate was again mild and all glaciers had disappeared, even from the mountains and the polar regions. He would have had before him all the effects of the former glaciation, the glaciated surfaces, boulder clays, erratics, moraines, etc., but the agencies he would find at work would be nowhere producing such effects—neither winds, rivers nor waves. He would be at a complete loss for an explanation of them.

In the absence of any true explanation of the drift, what explanations were offered? There were numerous guesses, but the ones most widely adopted were either some catastrophe or convulsion of nature, usually the Noachian deluge, or, more conservatively, floating ice.

Consider first the hypothesis of catastrophe. Geology was in its infancy. The ordinary geological agencies, especially stream erosion and deposition, had not been studied in detail, and there was little appreciation of the large results of slow processes working through long periods of time. Indeed there was no general belief that the earth's history was long; lack of knowledge, plus the generally accepted Genesis account of the earth's origin, made it natural to assume that its history was short. At the same

time, even a slight acquaintance with the disturbed rocks of the earth's crust showed that stupendous changes had taken place. The combination of these two views meant catastrophism, the belief that geological history was a series of convulsions.

As an example of catastrophic explanation we may quote Saussure's Explanation of the Origin of Rolled Pebbles (and erratics?) (1787): "When the waters of the ocean in which our mountains were formed still covered these mountains, a violent earthquake suddenly opened great cavities that had previously been empty. The waters rushed toward the abysses with extreme violence, proportionate to the elevation that they then had, cutting deep valleys and sweeping along immense quantities of earth, sand and fragments of all sorts of rock. This semi-liquid heap, pushed by the weight of the waters, piled up to the heights where we still see many of these scattered fragments. Then the waters, continuing to flow with a rapidity which diminished gradually in proportion to the diminution of their elevation, swept away the highest parts, little by little. They purged the valleys of this heap of mud and débris, leaving behind only the heavier masses and those whose position or more solid state protected them from this action." For unchecked speculation this would be hard to beat, but it should be remembered that Saussure has large and solid contributions to geology to his credit.

There was one available catastrophe right at hand in the Biblical deluge, generally accepted as fact by both layman and scientist, when "all the fountains of the great deep were broken up, and the windows of heaven were opened . . . and all the high mountains that were under the whole heaven were covered." Given this situation, anything might happen and it was easy to explain the drift. Silliman (1821) admitted that the drift was "very inadequately accounted for by existing theories," and wrote (1824), "No one will object to the propriety of ascribing very many, probably most of our alluvial features, to that catastrophe—the deluge of Noah." He himself suggested "enormous caverns in the bowels of the earth—which collectively, or even singly, might well contain more than all our oceans. . . . If these cavities communicate in any manner with the oceans, and are (as, if they exist at all, they probably are) filled with water, agents very competent to expel the water of these cavities, and thus to deluge, at any time, the dry land are at hand." Pages of similar views, often by men of high scientific standing, could be quoted; it would only witness to the control of tradition, and to the extremes to which even able men would go, in order to explain the inexplicable. It is not easy to say "I do not know."

A saner explanation of the drift was that it was brought to its present position by floating ice at a time when large sections of northern Europe and America were beneath the sea. This theory appealed to existing agencies, for both icebergs and shore ice were known to transport rock debris, and could be checked. Lyell's first edition of the "Principles of Geology" was published in 1833, and in it he seems to look the drift steadily in the face and pass by—a not uncommon way of meeting difficulties. In the first edition of the "Elements of Geology" (1838), published when Agassiz was beginning his studies, Lyell does not distinguish, among surface deposits, between residual soils, glacial till, and waterlaid sands and gravels. He does consider glaciated surfaces, and especially the erratics, and appeals to floating ice at a time when the sea stood at a higher level with reference to the land. "Icebergs then, detached from glaciers, together with coast ice, may convey for hundreds of miles pebbles, boulders,

sand and mud, and let these fall wherever they may chance to melt, on submarine hills and valleys. These, when the land emerges from the deep, may constitute some of the far-transported alluvium which has been ascribed to diluvial agency." To this explanation of the lowland drift Lyell clung for several decades.

If—Then, or Faulty Method

How was scientific method applied to these early theories? So far as concerns the catastrophe and deluge explanations, it just was not applied. The iceberg theory, however, is serious science, and it will pay to study its treatment.

Science advances by the solution of problems. The proposed solution of any problem we call an hypothesis. The thing to do with an hypothesis is not to accept it as true, but to test it in order to verify or invalidate it. *If* the hypothesis is true, *then* certain things follow. Verification of an hypothesis consists first in the skilful development of its implications, and then in the often long and hard work of checking such implications. The hypothesis may flash on the mind which is prepared, from no one knows where. The verification may take months or years.

The problem we are considering is the origin of the drift, of which the erratics are the most conspicuous feature. Lyell's hypothesis was that the drift was brought to its present position by floating ice. This necessitated extensive land submergence. What were some of the implications of the hypothesis, and how should the geologist have gone about testing it? If the hypothesis were correct, there should be independent evidence of land submergence, as suggested under the following points:

(1) The nature of the drift. If the drift was laid down in marine waters it should be stratified and contain marine fossils. Students were thrown off here, because there is almost everywhere stratified material associated with the drift, not only over its surface, but throughout its mass,—sands and gravels due to the melting waters of the glacier. Hence it was easy to believe that the whole mass had one origin and was waterlaid. In the absence of any competing theory of direct ice deposition, and so of any attempt to develop deductively criteria of deposits of differing origin, fine unstratified clays, often many feet thick, with scattered boulders of all sizes and practically without fossils, were unthinkingly accepted as waterlaid.

(2) The amount of submergence required is important. It must have been at least as deep as the height of the highest continental (as distinguished from mountain glacier) drift and rock scorings above the present sea-level, which is several thousand feet. This should have put a severe strain on the hypothesis.

(3) The limits of the drift should by hypothesis have been the limits of the water bodies in which the drift was dropped by floating ice, and should be marked by the characteristic features of wave action, by cliffs, beaches, etc. No such inference was made, and no such evidence sought; had it been sought it would not have been found, for it does not exist. There are, indeed, shore features which mark lower land-levels and the borders of temporary lakes, but they are within the area of the drift and not about its border; they do not reach heights above sea-level at all comparable with those of the higher drift, and they rest on the drift and are later than rather than contemporary with it.

(4) A further question might have suggested itself: Are the scorings on the bedrock of the kind drifting ice would make? It would be hard to explain the parallel flutings of the typical glaciated surface as due to the accidental grounding of floating ice.

Such are some of the implications of

the iceberg hypothesis which might have suggested themselves under a somewhat rigorous application of the scientific method. The evident conclusion would have been that the drift was not brought by floating ice. That would have left the geologists of the time without any valid explanation of the phenomenon.

Agassiz, Father of Glacial Geology

It was Louis Agassiz, Swiss biologist, who one hundred years ago started glacial geology on its career when he used the summer vacation of 1836 to go with his friend Charpentier into the upper Rhone valley to study its glaciers. Charpentier believed in a former vastly greater down-valley extension of the Alpine glaciers. Agassiz went a sceptic but returned a convert. Together the two men tracked the former courses of the glaciers by the polished and grooved surfaces of the bedrock and by the debris, down the mountain valleys and out across the broad valley of northern Switzerland to the slopes of the Jura. Though Agassiz continued field work through successive summers until the eve of his migrating to America in 1846, the whole matter of the former greater Alpine glaciation was worked out in that first summer; and in the fall of 1837 Agassiz outlined the whole subject in masterly fashion in his presidential address before the Helvetic Society of Natural History. The work of the later seasons dealt largely with the physics of the glacier, which does not concern us here.

It was one thing to demonstrate the former greater extension of the present glaciers of the Alps; it was quite something else to show the former existence of glaciers in a country where there are none to-day. In 1840 Agassiz visited England, and, with Buckland as his guide, found in the Highlands of Scotland, in the Lake District of northern England and in Wales, glaciated surfaces and glacial moraines similar to those with which he had become well acquainted in the Alps. In November of that year he presented his evidence before the Geological Society of London.

Agassiz's two volumes on glaciers, "Études sur les Glaciers" and "Système Glaciare," were published in 1840 and 1846. In America, after 1846, his zoological work claimed almost all his time, but he never lost interest in his glacial geology. He noted evidences of former glaciation in New England and New York, and he occasionally spent some time in the field, as in Maine in 1864. In 1866 in Brazil, he thought, mistakenly, that he had found evidence of ice action; and in 1871, only two years before his death, on his voyage in the *Hassler* to South America, he met his old friends the glaciers along the Straits of Magellan and on the southern coast of Chile.

How come it that Agassiz, Swiss biologist, is known as the "father of glacial geology"? This double-barrelled question, why a Swiss? why Agassiz? requires a double answer.

Why a Swiss? Geology differs from most sciences in that its investigations are geographically determined. Rocks vary greatly from place to place, in age, in structure and in surface expression; and the phenomena of geology have to be studied where they are found. It was no accident that stratigraphic geology took its rise in central England under William Smith; and with Cuvier and Broignart in the Paris basin, where gently inclined beds shingle out on the surface in such wise that the order of vertical succession is easily seen. The great contributions to pre-Cambrian geology were made by the geologists of Canada, the northern United States and Scandinavia, working in the great Canadian and Scandinavian pre-Cambrian areas. Glacial geology has inevitably had its beginnings in a region of existing glaciers, the Alps. There are, of course, glaciers in other

parts of the world; in Alaska, Chile, India, Greenland, Antarctica; but in 1836 these regions were practically unknown, far removed from any center of scientific activity. The Alps were near at hand and accessible. If there was to be a father of glacial geology, the odds were heavily in favor of some scientist living near their borders; he might have been German, Austrian, French or Swiss. Actually he was a Swiss.

Why Agassiz, the zoologist? It was partly chance, but more the man. Suppose he had taken that vacation at the shore? Apart from chance, it was largely Agassiz's personality. Agassiz was not the first to appreciate the evidence of former greater glaciation. The German Kuhn had seen it as early as 1787. So had Venetz in 1821, Bernhardi in 1832, and Charpentier had the whole matter correctly in 1834. Indeed, it was Charpentier who introduced Agassiz to the glacier. But put a man of boundless physical and mental energy on a problem, and no one can tell how far he will go. Agassiz was twenty-nine, in the full strength of early manhood, when he began his glacial studies, a fiend for work. "The day ought to have thirty-six working hours," he complained. He was doing full-time zoological and paleontological work and printing the illustrations of his works, when he took on this additional glacier problem. He was an ardent pedestrain, and in the Alps "delighted in feats of walking and climbing." His wide-ranging philosophical views of nature at once connected his field studies with extensive recent changes in life and in continental development. Add to this energy and enthusiasm the fact that throughout life Agassiz was a man of great personal charm and an eloquent speaker, and it is easy to see how, without consciously intending it, he stole the whole show. It was not that he appropriated or disparaged the work of his predecessors, for he did not. Rather, his energy, enthusiasm, and the charm and skill of his presentation swept the field.

Agassiz's Errors

Agassiz's work on glacial geology is not without admixture of error, and it is instructive to note the sources of these errors. To a very limited extent they concern minor items in his description and interpretation of field facts. "Erratic blocks of the Jura . . . reposing on a bed of cobbles and pebbles . . . well-rounded and heaped in such fashion that the largest are on the top, while the smallest, which grade to a fine sand are occupying the base and resting directly on the polished surfaces"[1] does not read like an adequate description of the drift. Careful petrographic study of the drift had not begun. Agassiz's major mistakes, however, did not arise from the direct interpretation of immediate field facts; they came from speculations going well beyond any legitimate inferences from his own field work. In his earlier writings he assumed:[2]

(1) Polar ice-caps in both hemispheres, the northern ice-cap extending south and covering Asiatic Russia and Europe to beyond the Mediterranean, and all of North America.

(2) That at this time the Alps had not been elevated.

(3) That with the elevation of the Alps "this ice formation was raised like the other rocks; the fragments broken from all the crevices during the upheaval fell on its surface and without being . . . rounded moved down this great sheet of ice."

(4) "As the ice melted, it formed great funnels in the places where it was thinnest; valleys of erosion were cut in the bottom of crevasses in localities where no stream could exist without being encased in walls of ice."

[1] K. Mather and S. L. Mason, "Source Book in Geology," p. 232, 1939.

[2] *Ibid.*, p. 334.

To polar ice-caps Agassiz long adhered. He writes in 1866: "Two vast caps of ice stretched from the northern pole southward, and from the southern pole northward, extending in each case far toward the equator."[3] Centering the ice-caps at the poles was a not unnatural mistake. In Europe the direction of the ice movement was in general to the south, northern Europe and America were unknown, and years of field work were necessary before it could be shown that the glaciers moved radially out from land centers—in Europe from Scandinavia, in Canada from Labrador and from the Great Plains west of Hudson Bay. His statement, of course, carries the southern limit of the ice-cap too far to the south.

While the mistake just mentioned was due to speculation which ran ahead of any available field evidencce, items 2 and 4, which are more poetry than science, rest back on a basically false scientific philosophy, uncritically assumed by one who was temperamentally inclined to wide-ranging theories. Darwin's "Origin of Species" was not to be written for nearly a generation. Lyell's uniformitarianism, the doctrine that the earth's past history is to be explained by present agencies of change acting at essentially present rates, had little hold on scientific men. Genesis was still considered in many quarters good science. If, according to Genesis, time was short, and, according to geology, great changes had been frequent, catastrophism was a necessary conclusion. Agassiz belonged to this school of thought. Writing as late as 1866 he held that "a sudden intense winter, that was to last for ages, fell upon our globe . . . and so suddenly did it come upon them (tropical animals), that they were embalmed beneath masses of snow and ice, without time even for the decay which follows death."[4] In such fashion he accounts for the woolly mammoth mired in the soils of northern Siberia. This doctrine of catastrophe found supposed scientific warrant in the writings of Cuvier (1769–1832), who gave it expression in his "Révolutions de la Surface de la Globe" (1825). Cuvier's scientific reputation gave his opinion in this matter a weight beyond any warranted by the facts; and Agassiz, who as a youth had worked in Cuvier's laboratory and was his life-long admirer, doubtless was influenced by the older man. Certainly the statements, 2 to 4 above, have little reference to actuality.

Let no comments on Agassiz's errors discredit his solid contributions to geology. He it was who started glacial geology on its course. He was a land-ice man from the beginning to the end. It is credit enough to be the father of glacial geology. If the father made occasional mistakes in bringing up his offspring, what father does not?

The Reception Given the Glacial Theory

The glacial seed fell on soil both fertile and stony. Edward Forbes wrote Agassiz (1841):

> You have made all geologists glacier-mad here, and they are turning Great Britain into an ice-house. Darwin, who was both geologist and biologist, applied the new views to the explanation of field facts in North Wales. Lyell (1840) presented a paper "On the Geological Evidence of the Former Existence of Glaciers in Forfarshire."

Others opposed, some, like von Buch, violently. Humboldt wrote Agassiz, "Your ice frightens me." Not unnaturally, when it is remembered that Agassiz's views included not only greater Alpine glaciers and former glaciers in regions not now glaciated, but immense polar ice-caps covering much of the lowlands of Europe and America. Murchison (1842) wrote,

> Once grant to Agassiz that his deepest valleys of Switzerland, such as the enormous Lake of Geneva, were formerly filled with snow and ice,

[3] "Geological Sketches," p. 212.
[4] *Ibid.*, p. 208.

I see no stopping place. From that hypothesis you may proceed to fill the Baltic and the northern seas, cover southern England and half of Germany and Russia with similar sheets. . . . So long as the greater number of the practical geologists of Europe are opposed to the wide extension of a terrestrial glacial theory, there can be little risk that such a doctrine should take too deep a hold on the mind. The existence of glaciers in Scotland and England (I mean in the Alpine sense) is not, at all events, established to the satisfaction of what I believe to be by far the greater number of British geologists.

And later (1849) he wrote Agassiz,

When are we to have a "stand-up fight" on the erratics of the Alps? . . . In a word I do not believe that great trunk glaciers ever filled the valleys of the Rhone, etc.

The successive editions of Lyell's "Principles of Geology" and "Elements (or Manual) of Geology" may be taken as giving the orthodox view of glacial geology. Before Agassiz, it is the iceberg hypothesis. For two decades Lyell refused to accept the Jura erratics as "part of the doings of Charpentier's great glacier," preferring to explain them by submergence and floating ice. In 1857 Lyell went to Switzerland, "being desirous to see the proof with my own eyes." He then wrote, "the entire absence of marine remains in the associated (rocks), the conformity of the distribution of the travelled blocks here with the shape of so many valleys, and above all, the sight of the Alpine snows . . . has made me incline strongly to embrace the theory of a terrestrial glacier";[5] and he did! For an explanation of general lowland glaciation, however, Lyell clung almost, if not quite, to the end (he died in 1875), to the iceberg hypothesis. There is an inconclusive reference to the "Greenland continental ice,"[6] but one looks in vain in the last editions of Lyell's works for any clear recognition of land ice in the great glaciated areas of Europe or America.

[5] "Life of Sir Charles Lyell," Vol. II, p. 250, 1881.

[6] "Students' Elements of Geology" (Seventh ed.), p. 170, 1871.

It may help us to understand Lyell's conservatism if we consider that he was forty when, in 1837, Agassiz first proposed his land-ice theory, and then recall a statement of Darwin's concerning Lyell in his own "Autobiography," "When I made any statement to him (Lyell) on geology, he never rested until he saw the whole case clearly. . . . He would advance all possible objections to my suggestion, and even after these were exhausted, would long remain dubious."

For some reason the Americans seem to have been more open-minded. Dana's "Manual" contrasts favorably with Lyell's "Principles" and "Elements." Dana writes, "In view of the whole subject, it appears reasonable to consider that the glacier theory affords the best and fullest explanation of the phenomena over the general surface of the continents, and encounters the fewest difficulties. But icebergs have aided beyond doubt in producing the results along the borders of the continents, across ocean channels like the German Ocean and the Baltic, and possibly over great lakes like those of North America. Long Island is so narrow that a glacier may have stretched across it."[7] In his second edition Dana sets forth the two theories, with reasons for and against, abandons the iceberg hypothesis completely and concludes, "It hence appears that the glacier theory is alone capable, as first shown by Agassiz, of explaining all the facts."[8]

Still, some American geologists fought against the theory to the end. Sir William Dawson, in his "Acadian Geology" (edition of 1878), and later in 1893, argued against it.[9] Among the reasons he gave were the following:

[7] "Manual of Geology" (First ed.), p. 346, 1863.

[8] "Manual of Geology" (Second ed.), p. 537, 1874.

[9] Summarized by G. P. Merrill, "Contributions to the History of American Geology," Rept. U. S. National Museum for year ending June 30, 1894, pp. 521, 573, 1896.

(1) The temperate regions could not be covered with a permanent mantle of ice, under existing conditions of solar radiation.

(2) It was physically impossible for a sheet of ice to move over an even surface and striate it in uniform direction over wide areas.

(3) Glaciers could never have transported the large boulders and left them in the positions where they are now found, for they are often at higher levels than the ledges from which they came, and anyhow, as no rock masses rose above the surface of the supposed glacier, there was no source from which they could have been gathered!

One wonders at the method of approach; this setting up a priori objections against field facts, rationalistic argument in preference to holding close empirically to the field evidence. It raises an interesting question in logic; when reasoning shows that an event could not have taken place, and a reasonable interpretation of field evidence shows that it did, which is one to believe? As late as 1893 Dawson was assuming former submergence of drift-covered areas, with currents sweeping down from the north, eroding valleys such as those of the Great Lakes, and carrying debris, including immense erratics, widely over North America. Newberry, commenting earlier on Dawson's views, says, "The difficulties in the way of this theory are such, however, that I am sure Professor Dawson, clear-sighted and conscientious as he is, would abandon it if he could examine with his own eyes the surface geology of the Lake-basin and the Mississippi Valley."[10]

How are we to account for the long delay of many geologists, including some of high standing, in accepting the theory of continental ice-sheets? Various suggestions may be given; and it is probable that in individual cases more than one reason functioned.

The true scientist is a natural skeptic; he doubts until he is compelled to believe. He would be untrue to his calling did he otherwise. Wherever his actual birthplace, he is "from Missouri" and has to be shown. Darwin's comment on Lyell, quoted earlier, is relevant here. Delay such as this is creditable.

In geology the facts are out in the field; one has to go out and find them, often in places not easy to get at. The opinions of the armchair geologists have little weight in comparison with the findings of the field geologist.

Hypothesis, while based on facts, also runs ahead of fact. To verify the hypothesis of continental glaciers in all its detail, long continued field study over wide areas, largely unsettled, was necessary. Some delay was unavoidable because of lack of evidence. This was not true, however, concerning the fundamental question whether the drift was ice or waterlaid. The evidence on that was abundant and immediately at hand.

Personal bias of various sorts plays its part. Traditional belief and authority have a larger influence in science than is usually admitted. Statements of supposed scientific fact are passed down from decade to decade, from text to text, until someone keener than the rest shows their falsity.

The scientific atmosphere of the time is an important, though usually an unconscious, influence. This was doubtless the source of Agassiz's catastrophism.

Then there is pride of opinion. Even a scientist may not want to admit his error if he has been prominently committed to a view. Darwin writes of himself:

> I had also during many years followed a golden rule, that whenever a published fact, a new observation or thought came across me, which was opposed to my general results, to make a memorandum of it without fail and at once; for I had found by experience that such

[10] "Geological Survey of Ohio," *Geology*, II: p. 27, 1874.

facts and thoughts were far more apt to escape from the memory than favorable ones. Owing to this habit, very few objections were raised against my views, which I had not at least noticed and attempted to answer.

This is the scientific conscience at its best.

There is also plain human inertia that stands in the way of the mental readjustment required by new fact and new theory. One can not put new wine into old wine-skins. Views to which one has grown accustomed seem natural: new views, strange and often wrong. Indeed, Agassiz himself, in his own field of biology, is an example of this unwillingness to accept new theories. Darwin's "Origin of Species" was published in 1859. Agassiz, until his death in 1873, was an active opponent of evolution. If one seeks an explanation, he enters on a study of personal bias and prejudice, due to the conflict of new views with other general and specific beliefs which had long been erroneously held as true.

We seem to have been giving the men of science pretty rough treatment? But this is only one side of the picture: the errors against which they must guard. On the other hand, no better delineation of the ideal scientist could be given than this, by Josiah Parsons Cooke, professor of chemistry for many years in Harvard College:

The great pioneers of science have been men of ideals, but men whose vivid imaginations were regulated by education, and chastened by wisdom. They have been men of courage and perseverance, who followed out their convictions through every discouragement. They have been men of entire truthfulness, who have never hesitated to submit their doctrines to the test of experiments and to abide by the issue. They have been men of the most scrupulous conscientiousness in attention to minute details, regarding themselves as responsible to the Giver of all truth for accuracy in every observation, and for exactness in every statement. Finally, they have been men of modesty and of reserve in judgment, realizing, as no other men ever have, how boundless is truth; how limited knowledge; how intricate the problems of nature; how weak in comparison the intellect of man.

One or More Glacial Periods?

A matter of the highest importance in glacial geology is whether there were one or more glacial periods. When Agassiz first showed the former greater extent of glaciation, it was of course natural to speak of *the* glacier and *the* glacial period; no other assumption was warranted. Later, forest beds and soils were found buried within the till, both in Europe and America, separating an upper and a lower till. This happened in Illinois in 1868, and soon after in Ohio and Minnesota. There were two possible interpretations of such discoveries. The advances and retreats of Alpine glaciers was common knowledge. Might not the continental ice sheet have retreated, and vegetation and even forests have grown over the surface of the abandoned drift, only to be overwhelmed and buried by the deposits of a readvance? If so, the two drifts would represent two epochs of a single ice period, the same glacier continuing in existence throughout the whole time. On the other hand, was it not possible that during the time between the two deposits the ice-cap disappeared from North America? There would then be two ice periods. An ideal place for solving the problem is the upper Mississippi valley, where the ice advanced to varying distances and the successive drifts can be easily studied. The work of McGee, Chamberlin, Salisbury, Calvin, Leverett and many others has shown that the lower and outer drifts are more deeply weathered and stream-eroded than the inner drifts; that where one overlies another the surface of the lower is often deeply weathered, and that fossil remains in the intervening beds indicate climates as warm as, or warmer than, that locality enjoys to-day. The longer and milder the intervening period, the more probable the disappearance of the preceding ice sheet from the continent. So the theory at first was—two separate glacial periods.

But it did not stop with two; continued detailed studies are now believed to show four glacial periods, separated by even longer interglacial periods, the time from the beginning of the first glaciation to the present time, which gives the length of Pleistocene or glacial time, being estimated at roughly a million years.

Now this is of the greatest importance, geologically. For while to the geologist as to the Creator a thousand years are but as yesterday when it is past, and as a watch in the night, a million years is nothing to be sniffed at; especially when it is the last million, the one connecting with our own time, and in which the finishing touches were being put in the earth's scenery and its life. Glaciers now cease to be merely an illustration of dynamical geology, of forces now at work on the earth's surface; they open the way to a long and eventful chapter in the earth's history. Great changes have taken place in that time. Some geologists believe that the carving of the Grand Canyon was done within that period. And it was the period during which man was slowly climbing from savagery to his present eminence in a civilization characterized by wholesale murder.

The Flowering of Glacial Geology

Glacial geology, like any growing science, shows increases in content, variety, complexity. The geological texts of today include many matters not dreamed of in the philosophy of Agassiz. To mention but a few, we have: The petrography of the drift; mountain summit and mountain valley sculpture by the snow field and the valley glacier; the long and involved history of the Great Lakes region during the retreat of the last ice sheet; the changes of land level; the sinking under glacial loading when the glacier was present, and the rise after its disappearance; and the bearing of such changes on our understanding of changes within the earth's crust; the working out in detail of the history of the glacial period, possibly a million years in length, and the changes during that time in the land surface, in plant and animal life and in man; the study of the vastly older glacial periods in pre-Cambrian and Permian time; speculations on the cause of glacial periods.

Refinement of Method

No advance in science is more important than that in method, for method is fundamental. Given right method, knowledge comes as matter of course. In the pre-scientific period of the subject, before Agassiz, there were floundering and wild guesses, often based on the Genesis myth, impossible of verification. Agassiz furnished the key which opened the door to genuine scientific advance; but for decades there was slow disentanglement from error, old and new. Science exists in the minds of its workers, who are human beings subject to the common mental infirmities. We have seen what some of these influences were which threw them off the track. They were subject to the general intellectual and scientific atmosphere of their time. They were limited in their outlook by the state of their own science at the time, by its scanty accumulation of fact and by its faulty theory. They were subject, as are all of us, to personal bias of various kinds. They had an inadequate appreciation of scientific method, especially as regards allowing for personal bias. There was throughout the nineteenth century a steady growth in understanding of the scientific method and an increase in the rigor with which it was applied; that is, a steady growth in the scientific conscience. Scientists became more critical of the work both of others and of themselves. In the field of glacial geology, with the increase of workers and the accumulation of field evidence,

old errors were detected and corrected. It should be noted that errors were corrected from within, by the geologists themselves, who had first-hand acquaintance with the facts, not from the outside.

So glacial geology has come limping along through its first century, ridding itself of error, developing its field both intensively and extensively, refining its method; and to-day it presents a very respectable appearance in the geological family.

Three glacial geologists of the highest scientific standing, Gilbert, Chamberlin and Davis, have made definite contributions to scientific method. Gilbert's paper[11] on "The Inculcation of Scientific Method by Example" is of the highest value, as by one who had a clear theoretical understanding of scientific method, and was also one of its best practitioners in America. Method, he says, should be taught, if it can be taught, not by abstract and generalized statement, but by concrete example, both in the classroom and in the field. The example Gilbert himself took was the variations in level of the old Bonneville shore lines about Great Salt Lake. Chamberlin's paper on "Multiple Working Hypotheses"[12] developed in detail a phase of the subject mentioned by Gilbert. William Morris Davis, in numerous articles, gives special attention to methods of study and presentation; develops "a conscious inspection of his own mental processes as a means of improving them"; and, by inference, those of his fellow geologists and geographers, who received his suggestions with varying degrees of enthusiasm. One will find the actual working of the scientific method nowhere better set forth than in the two papers by Gilbert and Chamberlin.

It may seem ungracious to pick on the mistakes of our predecessors and to drag them out for public discussion. But the theory of scientific method is one thing, and its practice is often quite different. And it may be that by the examination of its faulty working, and the errors which follow, we can best avoid errors ourselves. The progress of scientific discovery is more important than the concerns of the individual. The earlier investigators were pioneers, often working under unfavorable conditions, and they have the credit that belongs to pioneers. We honor them as the founders of the science.

11 G. K. Gilbert, *Am. Jour. Sci.*, 31: pp. 284–299, 1886.

12 T. C. Chamberlin, *Jour. of Geology*, 5: pp. 837–48, 1897.

GENETICS AND RANGE SHEEP IMPROVEMENT

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GENETICS has been one of the active fields of research with small animals for a long time. It has been a very successful field for research, and, because of this success, it was only natural to extend the experience with laboratory animals to our farm animals. In the beginning of farm animal breeding studies, the search for information pertaining to the biological phenomena governing inheritance was oriented around the discoveries of Mendel which activated unprecedented interest in research into the principles of inheritance in both plants and animals. Indeed, animal breeding received such an impetus after the rediscovery of Mendel's laws that some thought was held that it might become, to a very considerable degree, an independent science.

Like so many new developments in science, animal breeding for a while did not seem to have any well-defined and specific interphases. Perhaps here was a new field which might become exclusive and self-sufficient within its own horizon. Astronomy got under way as an independent development—star gazing. It, however, quickly reached its limit as an independent approach to a complex problem. Mathematics was first to come to its rescue. Later, chemistry and physics in their refined developments became very necessary interphases in astronomical science. In the various biological sciences, specialized as they seem to be within themselves, there is no end to the list of interphases. It appears that in no special phase of the very general fields of biology, chemistry, physics, etc., can one hope to make much progress without reference to a vast array of highly specialized and related fields.

As the research worker in animal breeding became more and more familiar with his new field, there appeared in rapid succession new frontiers, new barriers, new interphases. He rapidly became analytical-minded. It was not enough to explain, with some degree of accuracy, why the daughter of a gold medal cow is a star boarder; why many a son of the two-minute trotter is a disappointment, or why all the sons of a league baseball player "do not get to first base." The requirements necessary to explain these problems were but minor stopping-off places in a boundless, unexplored biological vastness. There were more complex barriers that had to be explored. He knew that he could not go around nor over these barriers for an answer to his questions. He must penetrate them.

We find him, therefore, gradually venturing off his own reservation to refresh himself in the special fields of biology, in mathematics, indeed, in biological philosophy. Upon these exploring trips he made discoveries which he would never have made had he not ventured into these fields. But, in his adventures, he acquired the wanderlust. He is off again seeking still newer frontiers.

In the fields of physiology and chemistry he encounters hormones, an endless parade of new ones. Here, he also hears rumors of gene organizers and morphogenetic substances that challenge his spirit of adventure, to say nothing of the stimulating influence it has on his philosophic concept of the complexity of life itself. He knocks at the door of the biochemist. He is thrilled with his researches in endocrinology. In his after-dinner quiet fireside hour he attempts to

explain the interesting matter of mutations. Suddenly he plunges headlong into the field of polarity. Of course, he must also analyze potential differences, which involve the field of force. He is now concerned with molecular physics, because it, no doubt, lies somewhere between the Alpha and Omega of cytogenetics. He may also request the physicist to speak of physiological gradients. And so on in endless procession he discovers unexplored terrain—new frontiers.

As a student of animal breeding he has found now that his approach to the solution of his problems reaches out so far that it goes somewhat beyond the more familiar categories of scientific thought, and he now seeks organization of thought and endeavor in the field of biological philosophy by means of which he hopes to understand and integrate the vast array of problems he encounters in his search for a solution.

Thus, for some time he has been attempting to satisfy his curiosity by adventuring into details that are fundamental to a fuller understanding of the complex problem of inheritance. He has become more and more analytical-minded. And, it is right that he should be analytical-minded. Indeed, he must be analytical-minded! But, he is still a student in animal breeding looking for a solution—looking for a means whereby he can raise the average efficiency in livestock on a fundamentally practical and sound basis. His interest in analytical detail must not, therefore, become a confusing element in his search for a solution—in getting his job done. Because of his detailed contact with the interphases—cytogenetics, physiological genetics, biochemistry, molecular physics, mathematics—he may have, in some cases, developed a temperament which is likely to find more comfort in the problems of analysis than he finds in the problems of synthesis; more comfort in working with an ever-increasing procession of smaller and smaller units, than he finds comfort in trying to synthesize these into a definite organic relationship. He must be familiar with, and have a workable knowledge of, details, but he must likewise be able to visualize beyond details in organic pattern, because, after all, the practical solution lies fully as much in the organization of detail into useful organic life as it lies in resolving organic life into details of structure. The developmental biologist is to-day deeply concerned in discovering principles fundamental to synthesis in development—to organization and integration in animal life.

The chemist meets with fair success when he attempts to explain the funda-

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DEVOTED EXCLUSIVELY TO RANGE SHEEP IMPROVEMENT UNDER NATURAL CONDITIONS.

SUMMER RANGE FOR RESEARCH FLOCKS

ALTITUDES OF 8,000 FEET ARE REACHED BY JULY. SUMMER GRAZING ABOUNDS ON FLOWERING PLANTS AND BROWSE UNTIL THE FIRST SNOWS BEGIN TO THREATEN SOME TIME IN SEPTEMBER.

mental aspect of how the individual elements get themselves built up into synthetic products. But ask the developmental biologist how the very minute elements of the nucleus get themselves built up into a complex organism! His answer will, in all probability, be less specific than is the answer of the chemist. Much of the biologist's answer, if indeed an attempt is made to make it fairly complete, will be philosophic in its approach.

Ask the animal breeder how successful he has been in making fundamental improvement. His methods have been largely empirical. What hope does this method offer for the future? He himself is asking this question. He is likewise asking, Does any other method offer more hope? And, he is expecting an answer. Science must do its part in supplying this answer. Research has led the way for the competitors of wool, for the competitors of meat. Research must likewise lead the way by not only improving the quality of wool and meat products, but it must lead the way in the efficient production of these products. It will require analysis, it will require synthesis to ably meet the challenge which the trusteeship involved has vested in the animal geneticist.

The improvement of our domestic animals through breeding has always been very largely an art, because its results have been approximate. With an ever-expanding knowledge of biological phenomena, the effort to make it a science has been increasing. It will become a science only to the extent to which we are able to acquire knowledge and control of Mendelian phenomena. Thus it appears that animal breeding offers good possibilities of remaining, in general, somewhat of an art as well as becoming in part a science. This condition must

EWES WITH TWIN LAMBS

LAMBS ARE TRAINED IN SMALL GROUPS TO STAY WITH THEIR MOTHERS BEFORE THEY ARE ASSEMBLED INTO REGULATION BANDS OF ABOUT 1,100 EWES WITH THEIR LAMBS.

not discourage the fullest application of science in our search for a solution.

Analytical genetics and the interphases have paved the way for our excursion into the field of creative genetics. Its task, however, has by no means been completed. It must continue to illuminate the path of progress in animal improvement and pave the way for further adventure. Analytical genetics must penetrate and explore the barriers; creative genetics must make full application of the explorations.

When we speak generally of analytical genetics we have in mind genotypic analysis, particularly with reference to the number or kinds of genes concerned in the inheritance of characters, their interactions and their linkage relations. The analytical geneticist has been able to write the genetic formula for a number of these, and has postulated the formula for many more. In general, those characters for which the gene patterns have been described are comparatively simple, and while they may be relatively unimportant economically they contribute to the fundamental exploring procedure. Many characters, however, that have already been genetically analyzed are fundamentally important. Perhaps the most significant of these are catalogued as undesirable recessives or defects, physiological as well as structural. Progress in quantitative analyses has not been so rapid.

The evidence that is available up to this time seems to indicate that those qualities in animals which have the most significant economic value are complex in their inheritance. The matter of size, as an example, in many kinds of animals is an important utility factor. At least one investigator of size in one of our laboratory animals, the rabbit, has worked for almost 30 years on studies

concerned with the inheritance of size. So far he has not identified one gene to which he can attribute a definite effect for size. In another laboratory animal, the mouse, one investigator has established one case of linkage between a size gene and a color gene. But to do this required several years and hundreds of mice. In Drosophila, it has so far been possible to identify only a few of the genes affecting quantitative characters.

The opinion seems fairly unanimous that the utility characters such as size, vigor, physiological performance, etc., are affected by many genes, and that, very likely, some of these are interacting in a very complex manner. Moreover, there is an interaction between genes and environment which obviously contributes to the difficulty of making a satisfactory genetic analysis of complex quantitative characters.

On the basis of this experience it would likely require many, many years and thousands of sheep to complete a genetic analysis of the utility factors in this species. And, if the gene pattern of every character were known, we would still be confronted with the task of combining the desirable genes into sheep that would be an improvement over those we now have, and this task might require fully as much time as the analysis. If as few as ten pairs of genes were involved in a given character, nearly 60,000 genetically different combinations would be possible. To bring order out of chaos in an analytical problem involving such numbers would require the courage of a Daniel, the determination of a Cromwell, the patience of a Job.

In the light of these conditions, when a general improvement program is undertaken, the objective must be very clearly defined. If the objective involves the improvement of sheep for range conditions, then, obviously, all the environmental details of that project must be typical of that sort of environment which generally characterizes the conditions under which the sheep are expected to serve the ranchman. This eliminates any artificial stimulation of growth and development beyond the customary practice of the out-of-door, go-and-get-it sort and the essential winter feeding program. While it would be of interest and some value to determine the ultimate potential development of these breeding sheep when placed under artificial conditions, this development could not serve as a very reliable measure in appraising values of usefulness in the open range country where hardiness, grazing qualities and ability to do well are so vital in seasons and years that vary considerably in food supply and climatic conditions. Obviously, the efficiency of the progeny relative to feed lot gains will be considered in the program. The improvement in the sheep must be the result of "seed" and not of "soil," of breeding and not of an artificial environment, in order that the same degree of success which characterizes their measure of excellence might be reasonably well assured under similar natural conditions. If, however, the environment is permanently improved over that which characterizes the general range conditions, the germ-plasm can accordingly be adjusted to conform with such environmental change. Nature will be an important element in the selection procedure.

There will obviously be an attempt made to analyze the inheritance of some characters in sheep in the Western Sheep Breeding Laboratory, particularly when such analysis will facilitate selection. But this part of the program will be secondary. Undoubtedly in an inbreeding program, which is designed to purify a line for desirable qualities, recessive characters will appear, and in some cases, the inheritance of these can be determined from data that accumulate in the natural course of development of other objectives in the program. If at

CORRAL AND CUTTING CHUTE

SHOWING METHOD OF SORTING LAMBS FOR RESEARCH DATA. THIS STATION IS AT AN ELEVATION OF 8,000 FEET AND CAMP SUPPLIES ARE PACKED ON HORSES. THERE ARE APPROXIMATELY 2,100 EWES AND LAMBS IN THE BAND.

some time in the future it is deemed advisable to attempt a genetic analysis of some of the more complex quantative characters, it would seem that sheep which have been subjected to judicious inbreeding for some time would be more suitable for such an analysis, because they would be more homozygous for the characters involved than they were before any inbreeding was done.

Experimental animal breeding has demonstrated very clearly that there is a marked variation in the genotypic constitution of animals within a breed and that the phenotype is not a satisfactory measure of the genotype. Progeny testing is one means of measuring the genotype, and it is a fairly satisfactory measure when adequate recognition is made of the matings involved. However, all phenotypically desirable progeny may not necessarily be a reliable measure of homozygosity for desirable qualities in the sire or dam of such progeny. Hybrids that are the progeny of parents representing two breeds are very often appreciably superior to their parents, while one parent or the other does not show superior progeny when mated to animals of its own breed. In this case the superiority of the offspring is likely not due to the homozygosity of one parent or the other for most of the good genes of sheep, but rather to the action of complementary genes originating in both of the parents. When breeds have been maintained separately for some time, it is generally conceded that they become somewhat differentiated in their genotypes, though the expression of the respective gene types in the phenotypes within these breeds may be somewhat

the same in outward conformation and in function.

When matings take place between strains or lines within a breed, heterosis operates in a similar manner, but usually to a somewhat lesser degree. Strains within a breed generally do not have the same opportunity to become genetically differentiated as do different breeds, because the influence of popular sires and strains sooner or later is felt in practically all prominent strains within a breed. When there is, however, enough genetic distinctness between strains to produce a material heterosis in their hybrids, this is not necessarily a clearcut measure of the homozygosity of each parent for dominant desirable genes, but rather an indication that there is enough genetic distinctness involved in the mating to effect heterosis. Obviously, one parent may contribute more to heterosis in the mating than the other parent. The relative homozygosity of each parent for dominant desirable genes will govern, to a considerable extent, the contribution from each parent to hybrid vigor in the progeny.

When individuals within a line that is highly inbred, and that are relatively homozygous for desirable genes are mated together, they generally do not produce as vigorous offspring as are produced when individuals from one line are crossed with individuals from another inbred line. Even though the foundation for two lines were equally homozygous for the same good genes at the beginning, they would differ after some generations of inbreeding because different combinations of genes would become fixed in the two lines. When two lines are crossed it is quite probable that heterosis in the progeny would be in proportion to the complementary genes in these lines.

It is probable that the maximum usefulness of inbred lines in commercial production will come from the heterosis obtained from such lines in outcrossing and crossbreeding. If this assumption is correct, then it follows that these inbred lines should be developed to their maximum reliability for this purpose. The ability to repeat desirable performance will likely constitute the major aspect of reliability, and this ability will, in general, be based upon the homozygosity for good genes of the individuals within a line that enter into crossbreeding.

Outcrossing tends to conceal, and not to expose undesirable genes. This type of breeding is most prevalent in commercial production, because it is apparent that the success of a commercial enterprise must not suffer the loss incident to the production of too many common lambs, that might arise at least in the relatively early stages of a close inbreeding program.

Inbreeding, though it is slight, tends to expose and fix undesirable as well as desirable qualities. The more intense the inbreeding in the comparatively heterozygous foundations from which such lines must originate, generally the more severe must be the culling. In some lines this culling may be so severe that it becomes difficult to maintain them. This is an obvious reason why undertakings of this nature should involve large numbers of sheep.

Lines will, probably, vary in the degree of inbreeding which will make them the most serviceable for outcrossing. Likewise, they will vary in their ability to endure inbreeding. For this reason attention must be given to the rate of inbreeding in the lines involved in such a program. Very intense inbreeding within a very heterozygous group would doubtless give rise to a larger number of undesirable segregates than would occur within a relatively homozygous group. Moreover, very intense inbreeding at the outset in a relatively heterozygous group might be the means of failure, and result in the discarding of a potentially suc-

CONTRAST IN WOOL COVERING OF FACE

THE "OPEN FACE" RAM HAS FULL USE OF HIS EYES. THE OTHER RAM IS "WOOL BLIND," A QUALITY WHICH HAS LITTLE IF ANY VALUE. UTILITY QUALITIES FOR RANGE PRODUCTION RECEIVE PRIMARY CONSIDERATION AT THIS LABORATORY.

cessful line in which some good qualities prevail that might be advantageously concentrated by resorting to a less intense program of inbreeding at the beginning, which would allow for more effective selection within the line.

Progeny testing is our best means of measuring the inheritance of sires and dams. Inheritance can not be measured before it has had an opportunity to express itself, hence progeny analysis. If the progeny of successive sons in a line show a successive increase in efficiency for outcrossing it would appear that they are becoming increasingly homozygous for the utility qualities desired. In making suitable progeny tests of successive sons in a line as the inbreeding proceeds, it should be possible to determine with some degree of accuracy how far inbreeding should proceed in the line to produce optimum results for outcrossing purposes.

Inasmuch as no two lines will likely carry the same complementary genes, in kind or number, one would expect a difference in the degree of success that obtained with the various combinations of lines that might be made. It would be unsafe to assume that the potential inheritance of any one line is adequate in itself and that it can not be improved through the introduction of genes from other lines. Therefore, when complementary qualities are discovered through progeny testing in outcrosses, and these are introduced by convergent crossing back to the inbred line, a means may be available for bringing together as many desirable genes as possible in individual lines. This may also prove to be a practical means of not only improving desirable inbred lines, but it may become a means of materially strengthening or, indeed, salvaging for a useful purpose in outcrossing lines that are unable to en-

dure a high degree of inbreeding. Such a system of hybridization could be used between lines and also between a line and relatively unrelated, heterozygous groups, the latter probably offering a bigger opportunity for general improvement in the breed as a whole. The crossing of rams from lines of known performance upon commercial flocks of mixed breeding, or crossbreeding, with controlled heterosis, would seem to be the field in which such rams will extend their influence most widely and most effectively within limited time intervals.

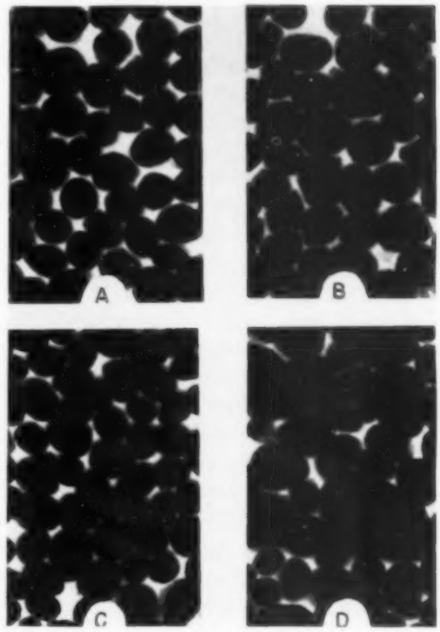
In an effort to develop relatively unrelated lines, the inbreeding program will bring about divergence between the lines, and eventually lines may be evolved that are especially useful for specific purposes. One line may evolve that is especially desirable for long staple; one for excellent mutton conformation; one for freeness from skin wrinkles, and still another for freeness from wool over the face or the "open face" character. When such divergence does arise in inbred lines, then such inbred animals can be used effectually for "corrective breeding," a practice which is much less effective when matings involve heterozygous animals. Moreover, these "specific purpose" inbred lines can be converged back into other inbred lines that are in need of the corrective character involved. Divergence between potential lines is already in evidence in the laboratory flock of Rambouillets for such characters as "open face," long staple, mutton conformation and freeness from skin folds. Inbreeding in the flock was under way about fifteen years ago, although it has become more intense in recent years. The approximate coefficient of inbreeding for the 1940 progeny from 805 ewes involved in 34 potential lines will be somewhat over eight per cent. It will be about 30 per cent. for the most inbred line and about 50 for the most inbred individual.

Creative genetics in sheep is definitely involved if and when progress is realized in bringing together a more homozygous combination of desirable genes. The analytical method gives some hope of accomplishing the desired combinations when characters have relatively simple gene patterns. When complex gene patterns are involved, as in quantitative characters, there may be more hope in a method such as inbreeding that will encourage a drastic reshuffling of the genes with a view of encouraging the production of segregates that are comparatively homozygous for desirable genes. Every new individual has a combination of germ-plasm that did not exist before. This combination, however, may or may not be desirable. Reference is made here to the production of such new gene combinations that are more homozygous for good qualities than those that have existed before—progressive inheritance. Individuals with such gene combinations should be more capable of transmitting desirable gene combinations than individuals relatively less homozygous for these qualities.

The animal breeder is deeply concerned with a desire to express uniformly in animal form and function the result of the best combination of utility genes that it is practically possible to combine. The method of approach in the effort to realize this desire is somewhat immaterial to him so long as the improvement is fundamental and is accomplished at a fairly encouraging rate. A mass attack upon the genotype through inbreeding offers encouragement as to rate of accomplishment, and, obviously, any measurable progress would be fundamental. By means of inbreeding there would be produced desirable as well as undesirable progeny. The percentage of each would be influenced directly by the genotypic constitution of the foundation animals which entered into the production of the lines.

It would be important, therefore, to get as much information as possible about the potential usefulness of a strain before too much effort is spent on inbreeding. Tests of potential inbred lines should be made fairly early in the inbreeding program, and it would seem desirable to make tests somewhat often during the development of the line in order to chart its development rather carefully. It would not seem necessary to test the line in each generation because, if the rate of inbreeding that is used for the line is rather slow, no great change in the homozygosity of the line would be expected to occur in one generation. There might, of course, be large changes in some individuals born within the line due to Mendelian segregation, and it would be hoped that these might become identified by suitable progeny tests. However, it appears important not to confuse the total change in the progressive inheritance within a line, with marked genotypic changes due to Mendelian recombinations in any one individual within the line.

Basically, it would appear that rams in an inbreeding program might be tested for four rather specific purposes, namely, their value for perpetuating their own line; for crossing with other inbred lines; for top crossing with unrelated purebred ewes and for crossing with ranch ewes. This obviously is a difficult assignment, and, in all probability, will be done with comparatively few rams within each line. Perhaps it would not be necessary to make all these tests in every line each generation, because it is probable that there would be a high correlation between the results of certain of these tests. It is difficult to test a ram for his value in perpetuating his own line, because the number of ewes within any one line is not large, and, in general, all ewes are needed each year within the line in order to provide replacements. There will be exceptions to



CROSS SECTIONS OF WOOL FIBERS

MAGNIFIED ABOUT 250 TIMES. BY MEANS OF THE MICROPROJECTOR THE VARIATION IN DIAMETER OF FIBERS CAN BE STUDIED. A AND B ARE SIDE AND BREECH SAMPLES RESPECTIVELY AND ARE RATHER UNIFORM. SAMPLES C AND D, SIDE AND BREECH SAMPLES OF ANOTHER SHEEP, ARE NOT UNIFORM. THE VARIATION IN D IS NOT ACCEPTABLE.

this, but they will be few. Obviously, if the ram proves successful, his female progeny can be added to the line. If he is not successful, then the service of the ewes spared from the line, for the sake of his test, is lost to the line for the duration of his test, and this loss may soon be felt in a reduction of ewe numbers in the line.

While the performance of a ram when mated to unrelated purebred ewes or even ewes of mixed breeding may not be definite measure of his performance when used within his own line, it will, nevertheless, be one means of measuring his transmitting qualities, after due consideration is taken of the heterosis involved in such matings. This part of

the program will require that consideration be given to an attempt at standardizing ewes set aside for ram-testing purposes, such standardization to involve the use of ewes for test purposes of the same general breeding and quality.

The "spade and shovel" work has just begun in creative genetics as applied to the improvement of sheep for practical efficiency in range production. The program offers possibilities in the proportion in which foundation animals that are used in the production of potential inbred lines carry desirable genes for the qualities sought and in the degree to which these can be fixed by selection and inbreeding. This may take the form of a temporary stimulant or of a more permanent benefit. The nature of the program of this laboratory should insure both, and by a rational procedure of the inbreeding program the temporary stimulant would naturally be supplanted by the more permanent one. Desirable rams that are the result of one or two generations of inbreeding may prove stimulating in outcrosses. This effect may prove increasingly permanent as the generations of inbreeding continue, providing, of course, there is a consistent increase in the homozygous condition of good qualities with successive generations of inbreeding.

It should be emphasized that the lines now under way at the Western Sheep Breeding Laboratory are not necessarily permanently closed lines, because we can not assume that the inheritance of these lines is adequate in itself and not subject to improvement by outside genes. These conditions are recognized in the program by introducing rams for test purposes, from time to time, with a view of discovering qualities that may not now obtain in the laboratory flocks. No one line can possibly possess the best of the qualities that are in all lines. Therefore, from time to time, crosses of lines that possess complementary qualities and outcrosses followed by convergent crossing back to the inbred line, will be made with a view of bringing together as many desirable genes as possible in individual lines. These can be fixed by further inbreeding. By means of this method it would seem that new gene combinations could be effected that will serve as a measure of how successfully creative genetics can be applied in sheep improvement.

SOME NATURAL HISTORY DESCRIPTIONS OF JAMAICA

By Dr. KATHERINE V. W. PALMER

ITHACA, N. Y.

THE beauty of the island of Jamaica, British West Indies, so impressed Christopher Columbus on a May day in 1494, as he sailed his caravels into a harbor and dropped anchor on the north shore, that he named the spot, Santa Gloria. The name passed into oblivion as did the original natives of the island, the Arawaks, and later the Spanish civilization, but the loveliness of the landscape has stood the test of time. Scenes in that region, such as the deep blue of the sea, the breakers over the coral reef and the wind sweeping through the leaning coconut palms fringing the shore, leave a mental picture that might be called the Santa Gloria of reminiscence.

Jamaica is one of the Greater Antilles. It lies south of the western end of Cuba and west of Haiti, being next to Cuba and Hispaniola (Haiti and the Dominican Republic) in size. Situated in the geographical center of the West Indian waters, the island was naturally in a key position in the historical development, trade and settlement of the Caribbean area.

After Columbus, Jamaica was occu-

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NORTH SHORE OF JAMAICA, NEAR WHERE COLUMBUS LANDED.

pied by the Spanish, who exterminated the natives but introduced the Negro slaves. The Spanish were conquered by the English whose rule has been maintained since.

For over 400 years the island has been visited or possessed by explorers, settlers, buccaneers, pirates, traders, planters, seamen, soldiers, slaves, merchants, naturalists, writers and tourists.

From that motley group whose lives in many cases were dominated by interests which may or may not have been allied to natural history, descriptions from their writings are brought together to show that though exploring, fighting, looting or studying, all have added pertinent points to the description of Jamaican nature study.

When Columbus returned to his patroness, Queen Isabella in Spain, and was asked what the island of Jamaica looked like, he crumpled a piece of paper in his hand and placed it before his inquirers. No more graphic description of the topography of the country has ever been given.

The Blue Mountains with mist-covered peaks from 5,400 to 7,360 feet high forming the mountainous northeastern region; the beautiful, deep interior valleys; the roughly cut, sink-hole (cockpit) country of the central and western limestone plateau; the mountains and swamps of the southern coast and the rivers cascading into the sea on the north are all crowded into an area of 4,450 square miles, 144 miles in length and 49 miles at its greatest width.

In contrast to Columbus's brief dem-

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BOSTON BEACH, JAMAICA.

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A COMMON COUNTRYSIDE SCENE, NORTH SHORE OF JAMAICA.

onstration of the general topography of the island are the paragraphs of enjoyable description which R. T. Hill, the geologist, indulges in when in 1899 he wrote of the reconnaissance work in the "Geology and Physical Geography of Jamaica."

Imagination pictures no more exquisite scenery than that which attends the ascent of Blue Mountain Peak. With increasing altitude panorama after panorama of tropical landscape unfolds in rapid succession. At Gordontown, nine miles north of Kingston, where the interior margin of the Liguanea Plain meets the mountain front, the ascent through the red-colored cliffs of the Hope River Canyon begins, which here, at an altitude of 900 feet, debouches into the gravel plain through a boca. A thousand feet above, the white buildings of Newcastle Barracks look like doves upon a housetop, yet we climb so far above them that they seem like toy houses below. At 2,000 feet the Plain of Liguanea with its cities and villages and the shipping of Kingston Harbor, grow smaller and smaller, and finally appear like a diminutive plaza below us. Sometimes our path clings to the side of steep declivities, with an apparently endless slope above and a bottomless chasm below. Again, it follows a knife edge from which we can see beyond, on both sides of the island, the waters of the Caribbean, so distant and so far below that no horizon can be distinguished where the gray of the sea meets that of the sky. Still higher, the forest-covered summits of the limestone plateau, with its rugged back coast border, appear below as an unbroken meadow.

Each step of the way is marked by wonders of the vegetal kingdom. At the foot is the semi-arid south coast chaparral with exogenous banana plants, cocoanut trees, native cactus, and acacias. Ascending Hope River Canyon the delicate deciduous flora of the island begins, while the cliffs are burdened with ferns—golden, silver and delicate maidenhair—besides numerous little flowers which find foothold in the rocks. From 1,000 to 4,000 feet, plantations of coffee are numerous, finding congenial temperature and moisture. At 4,000 feet the government has found environment for its cinchona farm. Above 6,000 feet, in an atmosphere of perpetual

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ROARING RIVER FALLS, JAMAICA.

humidity, tree ferns set in. In this tropical climate such alpine heights offer no obstacle to human environment, and to an altitude of 4,000 feet the slopes are well populated.

The Spanish sought gold in Jamaica but did not find it as a natural product. However, here were brought the gold and treasures plundered from Spanish territory of the New World. On the south side a long sand spit or sand-connected islands, the Palisadoes, extend out from the mainland like a finger crooked to protect the contents of a hand. Thus is formed a well-protected harbor for the largest city and capital, Kingston. At the tip of the Palisadoes is the remnant of Port Royal, the once flourishing city of buccaneers. To-day ships sail over the sunken city of gold and wickedness. Fishermen cast nets in water less than ten fathoms over the former rendezvous of notorious pirates and privateers.

It has been said that Port Royal of the sixteen hundreds abounded in wealth as well as in debauchery. It was called "The Store House or Treasury of the West Indies." Two or three thousand pieces of eight were wantonly squandered in a night. There Henry Morgan, Francis l'Ollonais, Roche Brasilliano and Bartolomew Portugues were the arch chiefs who came or dwelt but ruled in drunken revelry with a bloody sword. However, some pirates were naturalists, as revealed by the writings of John Esquemeling, pirate, who sailed with Morgan. Not only does he describe in detail the ways of pirates and Jamaican taverns but also of giant tortoises, the trees and fruits of Hispaniola, glow-worms, crickets, scorpions, caymen or crocodiles, birds, and none the least, the manatee or sea cow, which he speaks of as a fish.

After a long, tempestuous history, without warning, Port Royal's reign came to an abrupt and terrible close. Between 11 and 12 o'clock on June 7, 1692, as the council of the city sat in session and the inhabitants were going about as usual, a thunderous noise was heard and tremendous earth shocks occurred which split Port Royal in many places.

A first-hand account of that disaster is given by Sir Hans Sloane, the celebrated English physician, scientist and naturalist, who lived through the event. He said,

> . . . The ground heaved and swelled like a rolling, swelling sea; by which means several houses now standing were shuffled and moved some yards from their places. One whole street is said to be twice as broad now as before the earthquake; and in many places the ground would crackle and open, and shut quick and fast: of which small openings have been seen 200 or 300 at one time, in some whereof many people were swallowed up; some the earth caught by the middle, and squeezed to death; the heads of others only appeared above ground; some were swallowed quite down, and cast up again by great quantities of water; others went down, and were never more seen. These were the smallest openings. Others, that were larger, swallowed up great houses; and of some gapings would issue whole rivers of water, spouted up a great height into the air, which seemed to threaten a deluge to that part of Port-Royal, which the earthquake seemed to favour, accompanied with offensive smells, by means of which openings, and the vapours at that time emitted from the earth into the air, the sky, which before was clear and blue, was in a minute's time become dull and reddish, looking like a red-hot oven.

The above description is only a meager item in Sloane's contributions to the chronicles of the natural history of Jamaica. He was a doctor of physic to the Duke of Albemarle as well as attendant on the once pirate, Governor Sir Henry Morgan. Sloane spent fifteen months on the island. During that time he collected 800 plants, most of which had never been named. Skilled drawings of those plants, life size, may be seen in two large volumes published in 1707 and 1725.

Though Sloane's work represents great effort and accomplishment, he is followed by another physician-naturalist who similarly published, in 1789, a tome

on the natural history of the island. He states,

> Sir Hans Sloane hath not collected above 800 species of plants in all his travels: In Jamaica alone I [Patrick Browne] have examined and described about twelve hundred, besides Fossils, Insects, and other productions: . . .

The flora of Jamaica is represented by a luxuriant growth of thousands of species of wild and cultivated plants from the sea to the mountain tops. The traveler from the temperate zone becomes aware of a long list of unfamiliar names. The sour-sop, sweet-sop, breadfruit, tamarind, nase-berry, papaya, mango, custard apple, cacao, cashew, akee, lignum-vitae, pimento or allspice, star apple, banyan, calabash, yacca, annatta, West Indian ebony, Barbadoes Pride, cherimoya, allamonda are only a few of such a list. The breadfruit deserves special mention because of its introduction to the island in 1793 by Captain Bligh, of the ill-fated *Bounty*. Of all the trees which establish a unique sense of camaraderie, the silk cotton tree or Ceba ranks high. Perhaps this is due to one of its members having been singled out in that country by the special appellation of "Tom Cringle's Tree." For a description of that particular tree seen on the main highway between Kingston and Spanish Town, we go to Michael Scott in that vital, reckless sea story "Tom Cringle's Log":

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BLUE MOUNTAIN PEAK, JAMAICA, B. W. T.

> . . . a large umbrageous wild cotton-tree, which cast a shadow on the ground—the sun being, as already mentioned, right overhead—of thirty paces in diameter; but still it was but a dwarfish plant of its kind, for I have measured others whose gigantic shadows, at the same hour, were upwards of one hundred and fifty feet in diameter, and their trunks, one in particular that overhangs the Spanish Town road, twenty feet through of *solid* timber; that is, not including the enormous spurs that shoot out like but-

tresses, and end in strong twisted roots, that strike deep into the earth, and form stays, as it were, to the tree in all directions.

. . . The branches overhead were alive with a variety of beautiful lizards, and birds of the gayest plumage; amongst others a score of small chattering green paroquets were hopping close to us and playing at bopeep from the lower surfaces of the leaves of the wild pine (a sort of Brobdingnag parasite, that grows like mistletoe, in the clefts of the larger trees), to which they clung, as green and shining as the leaves themselves, and ever and anon popping their little heads and shoulders over to peer at us; while the red-breasted woodpecker kept drumming on every hollow part of the bark, for all the world like old Kelson the carpenter of the *Torch*, tapping along the topsides for the dry rot.

To-day the Negroes believe that tree is inhabited by "duppies" or ghosts.

One line in that unsurpassed Negro story of the Barbadoes and Jamaica, "The Wooing of Jezebel Pettifer," by Haldane McFall, reveals a common bit of natural history and a key-note of local color pertaining to the black population —"Through a break in the cactus hedge a white-robed figure stepped lightly into the yard."

The ubiquitous cactus fence so characteristic of the habitations of the colored people of the West Indies certainly deserves attention. The rows of barrel-cacti securely massed together is a device with which nature competes with barbed-wire entanglements for keeping stray chickens, goats, burros, pigs and humans from wandering beyond their rightful boundaries.

When 95 per cent. of the population of the island is negroid, they naturally become part of the landscape. Their common and constant "Good morning, Mrs."; "Good morning, Bokra, I beg you a tuppence," called from any and every part of the bush or road make a friendly accompaniment to a picturesque setting.

The Negro has added his bit to the observations on natural history, as may be revealed by the numerous examples in his long list of proverbs and sayings.

E. L. Palmer

THE UBIQUITOUS CACTUS FENCE.

Out of a collection of 1,383 proverbs about 578 are on elements of natural history. Some which seem pertinent and pithy are as follows: "Ebery John Crow tink him pickney white";[1] "Lilly bush sometime' grow betta dan big tree";[2] "Alligator lay egg but him no fowl";[3] "When morass ketch fire, land-turtle look fe mangrove tree."[4]

1 John Crow is a vulture (*Coragyps atratus atratus*) with black plumage. The young vultures are white when hatched but do not remain white. Meaning is: What is one's own is always best.

2 Small beginnings are not to be disdained.

3 Never look at a subject from one angle only.

4 Any port in a storm.

E. L. Palmer

WHISTLING FROG ON ITS EGGS

WHICH ARE LAID ON WET TRASH. THESE PARTICULAR EGGS WERE LAID IN A FLOWER POT.

The fauna of Jamaica consists mainly of innumerable insects, land snails, fish and birds. Mammals and snakes are conspicuous by their scarcity. There is only one indigenous land mammal, with the exception of about 30 bats. The mongoose was introduced to keep the rats down, but became in turn an agent of destruction of small animals. The interesting manatee or sea cow feeds in the estuaries or harbors. About five non-poisonous snakes are known, but all are rare. Lizards are a familiar sight, as is also the large, introduced toad, *Bufo marinus*, which emits a poisonous secretion when handled. At night, whistling frogs produce a constant chorus. These frogs are remarkable in that they lay eggs away from pools. The tadpole stage is spent in the egg.

The fauna and flora of Jamaica have been described best by Philip Henry Gosse, the English naturalist, who in 1844 devoted almost eighteen months on the island to the study of the natural history. He returned to England with 1,747 specimens of vertebrates, 11,675 specimens of invertebrates, 7,586 plants besides hundreds of seeds. But his contribution to the natural history of Jamaica was not so much the accumulation of such numbers of specimens as it was the writing of his first-hand observations of plant and animal in that classic, "A Naturalist's Sojourn in Jamaica," in which his thesis is clearly stated as "Natural History is far too much a science of dead things; a *necrology* . . . that alone is worthy to be called Natural History, which investigates and records the condition of living things, of things in a state of nature; . . ." Passages from Gosse would not give an adequate idea of the book, for it is a continuous description of plant and animal of land and sea. The book should be given *in toto*. As a sample of his style one may watch him with what he refers to in his "Birds of Jamaica" as the "gem of Jamaican Ornithology," the long-tailed humming-bird:

> While I was up in the Calabash tree, engaged in detaching the bunches of *Oncidium*, the beautiful Long-tailed Hummingbird (*Trochilus polytmus*) came shooting by with its two long velvet-black feathers fluttering like streamers behind it; and began to suck at the blossoms of the tree in which I was. Quite regardless of my presence, consciously secure in its power of wing, the lovely little gem hovered around the trunk, and threaded the branches, now probing here, now there, its cloudy wings on each side vibrating with a noise like that of a spinning-wheel, and its emerald breast for a moment flashing brilliantly in the sun's ray; then apparently black, all the light being absorbed; then, as it slightly turned, becoming a dark olive; then, in an instant blazing forth again with emerald effulgence.

With one's memory still clear with scenes such as the nights filled with many sounds of insects, the bell-like ring of a little frog and the synchronized flashes of hordes of fireflies lighting simultaneously about 22 times every minute as they give an impression of masses of lighted airplanes moving across the Hope River Valley, glimpses of Jamaica have been presented from a varied group of roaming and writing people; explorer-discoverer, geologist, pirate, physician-naturalist, narrator, fiction writer, Negro and naturalist. All have observed something in natural history and woven it into the fabric of the cloth of their descriptions. They would, as well as do we to-day, agree with that notorious adventurer, Captain Jackson, who wrote of Jamaica in 1642,

> Ye Temperature of ye Climent, and Salubritie of ye Ayre, may be very well deserned in ye good complection and long life of ye inhabitants, who here attain to greater age than those in many of ye neighbouring islands. It is likewise watered with pleasant Springs and fresh Rivers, and wanteth noe store of safe convenient Harbors for Ships, both on the South and North sides thereof. For briefe, it affords, or can produce, whatsoever, or most things, affected by man, either for pleasure or profit.

CONSERVATION IN PUEBLO AGRICULTURE

II. PRESENT-DAY FLOOD WATER IRRIGATION

By Dr. GUY R. STEWART

SENIOR SOIL CONSERVATIONIST, SOIL CONSERVATION SERVICE, U. S. DEPARTMENT OF AGRICULTURE

THE life of the modern Hopi and Zuni tribes is full of interest for the student of primitive agricultural methods. These people, since their first contact with whites, have clung to their ancient life with a devotion which has preserved much of their early ceremonial existence. In the same way their system of planting corn and minor crop plants has been far less affected than have the Rio Grande Pueblos with Spanish and American agriculture. Valuable light can therefore be shed upon the relics of early ways of growing the traditional corn, beans and squash of the ancients by examining the agriculture of the Hopi and Zuni cultivators.

The Hopi villages lie at the southern end of the high upland known as Black Mesa. The agriculture of these communities forms an interesting example of the manner in which simple conservation practices have been developed to enable the cultivators to live in the midst of a rigorous environment. The elevation at the villages is approximately 6,000 feet, but the plateau rises to about 8,000 at its northern end. This higher elevation gives an appreciably greater rainfall upon the upper portions of the plateau than the 12.7 inches recorded over a ten-year period at Keams Canyon. This greater upland precipitation provides run-off in the main canyons coming out from the upper mesa emptying between the first, second and third mesas on which the eight villages are located. In addition, there is an important seepage of moisture along the mesa top, producing valuable springs at various points below the upper mesa rim. This seepage also makes it possible to grow fruit trees, particularly peaches, at places along the upper mesa and on the sloping land adjacent to the uplands. The local run-off from the sides of the upper mesas is also caught in many places and supplies bean, squash and melon fields. This supplementary water is absolutely necessary for crop growth in view of summer temperatures from 95 to 98 degrees Fahrenheit, combined with strong, drying winds during the spring and fall periods.

The critical factor in the success of the Hopi corn crop is flood water run-off, which comes down the principal arroyos at irregular intervals after torrential rainfall descends upon the uplands. This flood flow fans out over the alluvial flats which lie to the south of the Hopi villages. During the growing season portions of the corn lands may receive run-off at three or four periods during June, July and August. In order that the flood water may be handled successfully, it is essential that the bed of the arroyo should be only slightly lower than that of the field on which it is to be diverted. The light dams of brush and earth which are thrown across the flood streams by the Hopi irrigators are a great aid in stopping gully cutting by preventing excessive deepening of the channel. If arroyos are unchecked so that cutting starts, a gully of twenty to thirty feet in depth may form in a few years, which lowers the flood water to a point where

—Stewart

BRIGHT ANGEL TRAIL OF THE GRAND CANYON

COTTON SEED HAVE BEEN FOUND IN SMALL RUINS ALONG THE LOWER PART OF THE TRAIL, INDICATING THAT THIS CROP WAS RAISED IN THE WARMER PART OF THE CANYON.

it can not be brought upon the land. Hence, regular use of flood water to spread it out and keep the arroyo beds filled with the sand and silt which the stream readily deposits is one of the important factors in successful flood-water farming.

Since the flood flow can not be controlled beyond diversion from the main stream, parts of fields at times may be washed out or other portions may be covered with a heavy deposition of silt and sand. This is one of the risks inherent in any such system of agriculture. It is minimized to a certain extent among the Hopi by the fact that a family may have a share in the clan lands inherited from mother to daughter, which will be located in more than one part of the flood plain. This arrangement of the land holdings also reduces the chance of crop loss from windstorms or from a heavy concentration of cutworms, which might occur before the family and friends could come out and pick them off.

The preparation of land for planting is relatively simple. It commences in late February and is completed during the spring months. Plowing has never been generally adopted among the Hopi, because of the danger of soil loss from wind erosion, during periods of high wind. In most cases the principal land preparation consists of digging out weeds and brush, either with the traditional wooden planting stick or wooden weed cutter, though some cultivators have adopted steel hoes and spades. Part of the older Hopi, however, still feel that steel or iron tools may dry out the soil and make the planted seed likely to suffer from drouth and, therefore, use nothing but the older wooden tools. Each family group generally prepares its own land, the men doing the major portion of the work, but the women and older children may at times be seen working with them. At the same time that the fields are cleared, brush fences and windbreaks are rebuilt on the lighter

—*Stewart*

TYPICAL FLOOD WATER FIELD ON THE FIRST MESA AT HOPI

soils, and new windbreaks will be put in upon fields which have not been planted during the previous year. Any available type of brush or branches may be used, and the same material will be allowed to stay in the ground even after it is defoliated, so long as the branches give some protection against wind action. In the melon and bean fields the old roots will be removed as part of the land preparation, but in corn land the stumps from the previous crop are ordinarily allowed to remain so that the new plantings will alternate with the old hills of corn. At the same time that the flood water lands are prepared for planting, the men whose families have terrace garden plots adjacent to one of the springs, work up the ground and prepare it for planting to chile peppers, onions and early sweet corn. The water of some of the springs is slightly saline, so that salts may accumulate in the upper soil and there may be a tendency for alkali hardpan to form. On such plots the cultivators will often spade up the soil to a depth of 14 to 18 inches, breaking up the hardpan and incorporating any crop residues left on the surface.

The first planting of early corn is ordinarily put out in the terrace gardens in early May, depending upon the season. In most of the villages an official known as the Sun Watcher observes the point at which the sun rises along the southern horizon, and the Town Crier will then announce that the time has come for planting early corn, watermelons and beans. The main planting of corn is not started until after the Town Crier announces that corn will be planted for the village Chief or Governor. This planting is a spontaneous tribute to their leader for his service in arranging ceremonials and advising in clan and village affairs. The organization of such a village planting party is partly wrapped up in mystical tradition

—*Stewart*

HOPI BRUSH CHECKS RECENTLY PUT IN TO CONTROL SOIL BLOWING

—*Stewart*

HOPI TERRACE GARDENS, NEAR THE WIPO SPRINGS, FIRST MESA
PHOTOGRAPHED WHEN THE LAND WAS BEING PREPARED FOR PLANTING.

—*Stewart*

HOPI BRUSH CHECKS PUT OUT IN SANDY LAND
DURING THE PREVIOUS YEAR AND NOW LARGELY DEFOLIATED. THESE THIN WINDBREAKS STILL GIVE SOME PROTECTION FROM SOIL DRIFTING.

—*Stewart*

LARGE EARS OF CORN

GROWN AT ZUNI, IN FLOOD WATER FIELD, ON RELATIVELY SMALL PLANT.

and is partly the result of long agricultural experience.

Upon the day set for planting, as the men start from their homes, the women of their family will observe an old Pueblo custom and dash a dipper or two of water over them, in order that the crop which they are to set out may not lack for rain water.

When the party of volunteer workers is gathered together, the men will first hold a short ceremonial smoke and breathe prayers for rain. Prayer sticks are next offered before a field shrine and a little corn meal is sprinkled in the six major directions—north, east, west, south, above and below. After these observances, the planters will start along one side of the field, spacing their planting about three to five paces distant from each other. The rows are located in between the rows of the preceding year and the hills alternated in distance in each adjacent row, so that no two hills are opposite each other, and all are set in new soil.

The planting technique that has been developed is simple and effective. The planter removes the surface soil with his foot and then digs a trough-like hole from twelve to sixteen inches deep. The damp subsoil which is reached at this depth is next loosened and from ten to twenty seed are dropped in the hole and covered with soil to a depth of eight to ten inches. This deep planting enables the plants to obtain the maximum advantage from the moisture present in the soil and allows them to develop a deep root system which can resist wind or the rush of excessive flood water. By the use of a large number of seed, a leafy clump of stalks is started which gives excellent protection to the central stalks when high winds blow at harvest time. These outer leaves may only be frayed remnants at harvest time, yet through their shelter the central stalks are able to grow and mature one or more large ears of corn which are set at the base of the stalk just at the level of the ground. The excess seed also gives sufficient plants so that a fair stand is likely to remain, even though mice or cutworms get into the field. It is often customary for foot races to be run by the planters at some time during their first day's work in a field. This is believed to be effective in starting the corn to growing rapidly.

After the planting is completed for the village Chief, other planting parties of friends and relatives are organized in each village, as only a few fields are planted at a time. The women of the family whose land is to be planted ordinarily provide a mid-day lunch for the workers and entertain them at a bountiful supper when they return home at

night. A great deal of pleasant social life in the villages is centered around these planting parties, while a similar exchange of labor and entertainment is a part of the work at the fall harvest of the corn crop.

As soon as the corn has sprouted, the soil about a hill is kept loose with a digging stick and weeds are removed with a weeding hoe. Some hills which are found to be badly whipped by the wind will be protected, when small, with circles of protecting stones and later with brush windbreaks. In many cases it can be noted that individual hills of corn are surrounded by low banks of earth to hold rain or flood water.

The Hopi cultivator gives his corn crop considerable attention during the early part of its growth. Weeds are cut with a hoe so as to conserve moisture during the time of its most rapid development. Portions of the field which fail to receive flood water from the first storms are leveled off or roughly trenched to promote a more even flow of water if later rains come.

At Zuni, the corn crop is still raised on fields which receive flood water, even though irrigation has been made available for part of the village lands. The ditch-irrigated fields have been planted to wheat and alfalfa, while lands used for corn since traditional times still grow this crop with some modification of the old procedure which was originally very similar to that used in the Hopi villages.

The Zuni corn fields have always been surrounded with a high ridge of soil around the outer edge of the tract to aid in retaining flood water. Such a bordering ridge might be eighteen inches to two feet high and three feet or more wide at the base. This border was formerly raised by hand, but with the increase in plowing at Zuni, the ridge may now be thrown up with several rounds of a

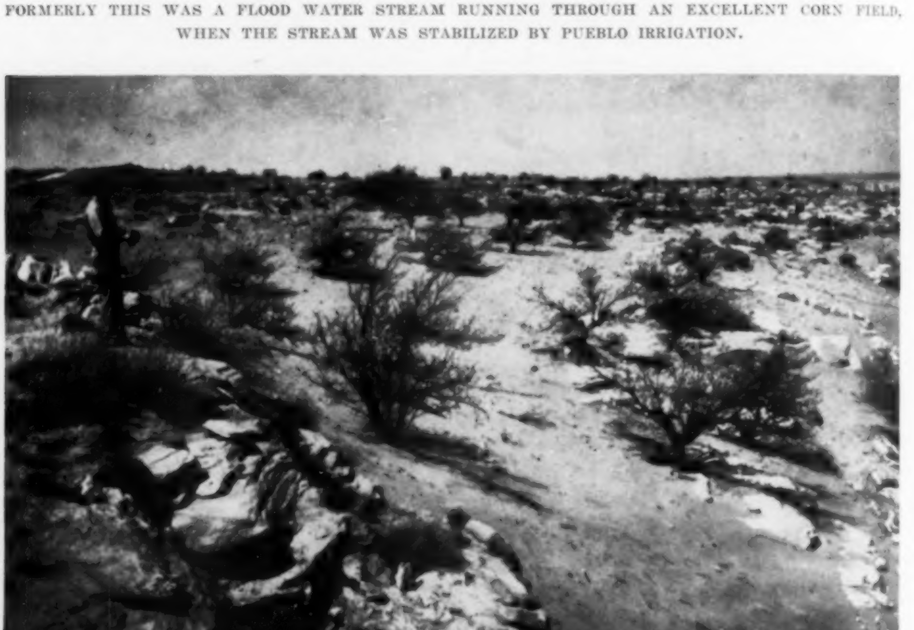
—Stewart

ZUNI CORN FIELD SHOWING THE CUSTOMARY EARTH BORDER
THROWN UP TO RETAIN FLOOD WATER.

—Stewart

"BOSTON GULLY" NEAR ZUNI VILLAGE

FORMERLY THIS WAS A FLOOD WATER STREAM RUNNING THROUGH AN EXCELLENT CORN FIELD, WHEN THE STREAM WAS STABILIZED BY PUEBLO IRRIGATION.



—Stewart

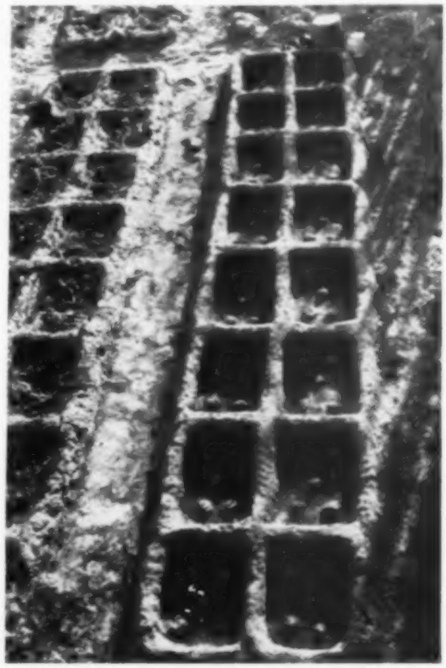
HOPI PEACH ORCHARDS, SECOND MESA, WATERED BY UNDERGROUND SEEPAGE

plow. Many of the Zuni streams furnishing flood water for patches of corn land have a less torrential flow than the arroyos coming out of Black Mesa near the Hopi villages. Consequently, the Zuni cultivator finds it easier to deflect the flood water out of the stream bed with a series of small brush-and-earth dams. At planting time a series of herringbone, radiating earth checks, extending out from the stream bank across the field, will have been thrown up. The brush and earth barriers across the stream itself deflect the water from the channel and spread it fairly even over the entire field with the help of the earth checks. The channel itself is kept up close to the level of the field so that this system of flood-water irrigation constitutes a wonderfully effective method of gully control. The more thoughtful Zuni recognize the value of these methods in preserving the land. On a visit to Zuni during the past summer the Governor of Zuni remarked to the writer: "Zuni farming always keeps the land good." Trouble at times may be experienced from excessively strong flow of water, washing out hills of corn, or too much sand may be deposited onto portions of a field, but spectacular gullying at least is prevented.

Not far from Zuni is a field which was farmed by Zuni cultivators for many years and was pointed out as an excellent corn field. About thirty-five years ago, in the realignment of the reservation boundaries, this field was placed outside the Zuni lands and went out of tribal control. The land was used for pasturage and flood-water irrigation ceased upon the area. Now the former flat stream has cut a deep channel, known as the Boston Gully, which is approximately seventy-five feet wide and twenty to thirty feet deep. It shows clearly that land under flood-water flow must be wisely and continuously used if it is to be preserved.

A series of river gardens are found along the stream banks, both at Zuni and in the outlying villages. These gardens are largely tended by the women and produce crops of chile peppers, onions, beans, early corn and a fair variety of introduced vegetables which have been added to the Zuni diet in recent years.

At both the Hopi villages and at Zuni,

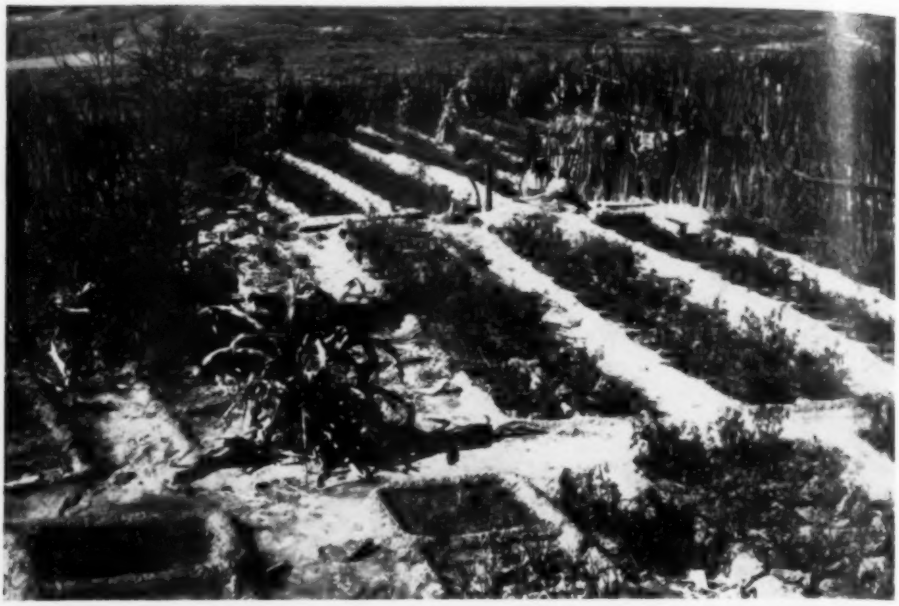


—*Stewart*

NEWLY PLANTED PLOT

ZUNI RIVER GARDENS. THE SEED IS PLACED IN A HANDFUL OF MOIST SOIL ON TOP OF THE GROUND.

the peach crop constitutes a valuable addition to the farming resources. Peaches were acquired at an early date, either directly from the Spaniards or from the mission fathers. In both places early observations of orchardists showed that there were areas adjacent to the mesas where seepage was present in the subsoil from underground run-off. The



—*Stewart*

A RIVER GARDEN AT ZUNI
IN WHICH CHILE, ONIONS, EARLY CORN AND VEGETABLES ARE RAISED BY THE WOMEN.

—*Stewart*

THE LARGE COMMUNITY VILLAGE OF PUEBLO BONITO, CHACO CAÑON
NEW MEXICO, WHOSE SIZE MAY HAVE CAUSED TROUBLE FROM OVERCROWDING IN PRE-SPANISH DAYS.

peach trees are raised from seed or cuttings and continue to produce for a long period of time. Many of the tops of the trees may pass their period of greatest productivity, but since few of the trees are on budded stock, shoots are allowed to come up from the base of the tree and after a time the new shoots become moderately productive once more. The peach trees are planted by individuals in common village or clan lands and belong to the person who sets out and tends the tree.

Summary

Probably some of the readers of this article will be interested to inquire what the causes were which led to the abandonment of many of the early agricultural communities of the southwest. So far as can be learned there was no one single factor which caused a shift in population and in occupancy of the abandoned villages. Several theories have been advanced for the complete disappearance of the Hokokam communities which formerly occupied the lower Gila and Salt River Valleys. The work of J. F. Breazeale, of the U. S. Department of Agriculture, and associated specialists at the University of Arizona has indicated that a compact, puddled, physical state of the soil may have resulted from the use of slightly saline irrigation water, without plowing or the incorporation of organic matter. This soil condition might finally have caused crop failures where no tool other than a wooden planting stick was used. Other students of this area have suggested a possible rise of the ground-water table, through the excessive use of flood water combined with slow drainage from the valleys. The sudden inroad of warlike enemies, during periods of food shortage in the surrounding country, with the loss of

—Stewart

REMAINS OF AN ANCIENT VILLAGE IN NEW MEXICO

AZTEC, WHICH WAS OCCUPIED DURING SEVERAL EARLY PERIODS, HAD IRRIGATION DITCHES AND WELL-LAID-OUT FIELDS.

many communities and the withdrawal of the survivors to the northern Pueblo country, is still another suggestion.

In the case of the northern Pueblos, there is good evidence that the great drouth of 1277 to 1299 caused the abandonment of the Mesa Verde villages. The other settlements at Cañon de Chelly and along the San Juan may have been given up either during periods of crop failure or as the result of wars and raids. In the case of the large communities, such as Aztec and Chaco Cañon, it is quite possible that some overcrowding with lack of sanitation, together with communicable diseases rising to epidemic conditions at times may have acted to depopulate them, combined with wars or crop failures.

There is no definite evidence of any great catastrophic change of climate throughout the region which would have wiped out agricultural plantings over a wide area, though undoubtedly local drouths, such as the serious occurrence at Mesa Verde, may have happened elsewhere.

We may, in fact, be justified in concluding that the system of agriculture based on flood-water irrigation developed through the Southwest was excellently adapted to a maintenance system of farming. The region, however, is one of rigorous extremes, and any one of a variety of unfavorable factors might intervene to throw the primitive cultivator out of balance with the environment from which he wrested a living.

WESTERN MIGRATION AS VIEWED IN 1855

EVER since Paleozoic times, therefore, the Oriental Continent—that is, Europe, Asia and Africa combined—has taken the lead in animal life. Through the Reptilian Age, Europe and Asia had species by thousands, while America was almost untenanted. In the later Mammalian Age, North America was yet in the shade, both in its Mammals and lower tribes; South America in still darker shadows; and Australia even deeper still. The earth's antipodes were like light and darkness in their zoological contrasts. And was there not in all this a prophetic indication, which had long been growing more and more distinct, that the Eastern Continent would be man's chosen birthplace? that the long series of living beings, which had been in slow progression through incalculable ages, would there at last attain its highest exaltation? that the stupendous system of nature would there be opened to its fullest expansion?

Another of our number has shown in eloquent language how the diversified features and productions of the Old World conspired to adapt it for the childhood and development of the race; and that, when beyond his pupilage, having accomplished his rescue from himself and the tyranny of forces around him, and broken the elements into his service, he needed to emerge from the trammels of the schoolhouse in order to enjoy his fullest freedom of thought and action, and social union. Professor Guyot observes further that America, ever free, was the appointed land for this freedom and union—of which its open plains, and oneness of structure, were a fit emblem; and that, although long without signs of progress or hope in its future, this land is to be the centre of hope and light to the world.

In view of all these arrangements, man may well feel exalted. He is the last of the grand series. At his approach, the fierce tribes of the earth drew back, and the race dwindled to one fourth its bulk and ferocity,—the huge Mastodons, Lions, and Hyenas yielding place to other species, better fit to be his attendants, and more in harmony with the new creation.

Partaking of the Divine image, all nature pays him tribute; the universe is his field of study; an eternity his future. Surely it is a high eminence on which he stands.—*From address of James Dwight Dana (1813–1895), delivered as retiring president of the American Association for the Advancement of Science at its annual meeting in Providence, Rhode Island, in August, 1855.*

THE CUCHUMATANES RE-VISITED

By Dr. OLIVER G. RICKETSON, JR.

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THE physiography of Guatemala is one of the most complicated in the world, consisting, as it does, of three distinct zones—a low coastal plain, a high central plateau, from five to seven thousand feet above sea level, and eleven major volcanic cones rising another five to seven thousand feet above the central plateau. These volcanic cones, from east to west, are: Pacaya (8,350 feet); Agua (12,110 feet); Acatenango (12,870 feet); Fuego (12,540 feet); San Lucas (11,790 feet); Atitlán (10,000 feet); San Pedro (9,570 feet); Zunil (7,050 feet); Santa María (active: 12,540 feet); Tajamulco (13,600 feet)[1] and Tacana (13,167 feet). These cones all follow along the Pacific margin of the central table-land, and offer a wild jumble of ridges and slopes mostly between 6,500 and 8,000 feet above sea level. Lake beds and canyon floors may lie as deep as 2,500 to 3,000 feet below the surafce of the plateau from which these volcanoes rise.

Although the volcanic peaks follow the line between the Pacific littoral and the central plateau, two main mountain ranges run easterly across Guatemala; they arise from two elevated land-masses in the west—the Sierra Madre southwest of, and the Cuchumatanes directly north of, Huehuetenango. We are here concerned with the latter mountains; they are of great interest to the archeologist, the ethnologist and the zoölogist on account of their inaccessibility and the fact that they present large areas above 10,000 feet with several isolation areas above 11,000. Their tops are composed of great undulating plains lying between rough, hilly country which may be better defined, however, as roughly rolling, when compared to the deeply dissected plateau region or the precipitous slopes of the volcanic cones.

The drainage of the whole mountain region comprised in the departments of Huehuetenango and Quiché is unusual and may be most clearly understood by glancing at the map (Fig. 1). On examination, this shows that the modern town of Santa Cruz Quiché—close to the ancient Quiché Indian town of Utatlán —stands on the narrow watershed between the headwaters of the Rio Grande-Rio Motagua system, which empties into the Caribbean, and the headwaters of the Rio Negro-Rio Salines system,[2] which empties into the Gulf of Mexico via the mighty Usumacinta. On the northerly slopes of the Cuchumatanes, steep, often palisaded, ridges extend northward from the main mass like fingers. These ridges throw the drainage into roughly parallel streams which are eventually absorbed into two river systems: on the northeast by the Rio Lacantun and carried by it to the Usumacinta; on the northwest by the Rio Grande de Chiapas and carried by it to the Rio Grijalva. This latter river and the Usumacinta have many inter-connections on the hot coastal plain of Tabasco, Mexico, before emptying into the Gulf of Mexico.[3] The modern town of Huehuetenango[4] stands on the narrow watershed between the, Rio Negro-Rio Salinas system and the

[1] The highest in Central America; for a full account, see Karl Sapper, "Los Volcanoes de la América Central." Halle, Germany, 1925.

[2] Also called the Rio Chixoy.

[3] P. C. Madeira, Jr., illustrates this coastal plain in Pl. 20 and the Usumacinta delta in Pl. 26. "An aerial expedition to Central America," *Museum Jour.*, Univ. of Pennsylvania, 1931.

[4] Near ancient Saculeu.

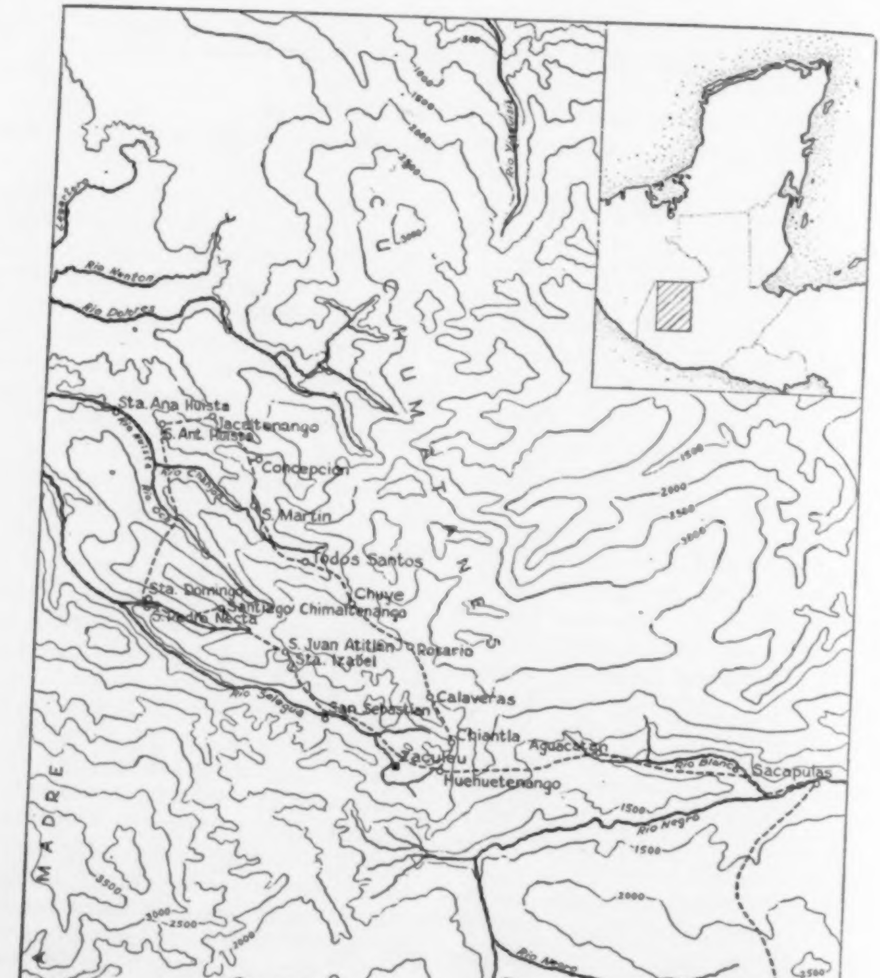

FIG. 1. MAP OF THE CUCHUMATANES MOUNTAINS

SHOWING THE REGION IN THE DEPARTMENTS OF HUEHUETENANGO AND QUICHE, GUATEMALA. TAKEN FROM CLAUDIO URRUTIA, MAP OF GUATEMALA. SCALE = 1 : 400,000. ROUTE SHOWN THUS - - - - -

Rio Grande de Chiapas system, just as stands Santa Cruz Quiché on its watershed. Bearing in mind that the topography of this whole area is generally so precipitous that even foot-trails must often follow streams or ridges to make travel possible, the location of two ancient sites of towns on watersheds should not be overlooked by the archeologist; their position would have been strategic from a commercial point of view alone; isolated, as the ruins are, on tongues of land surrounded by deep *barrancas* (ravines), they were also impregnable from the military point of view of a people without fire-arms, as is attested by Bernal Diaz's account of Utatlán: "When he (Alvarado) had made his entry (into Utatlán), he saw what a stronghold it was, for it had two gateways, and one of them had 25 steps . . . and the other entrance was by a causeway."[5] Alvarado barely escaped out of the city over this causeway before it was demolished; informers, as well as his observation of the fact that women and children had been removed from the town, apprised him of the intended fate of the Spaniards had they remained; the city was to have been fired and the Europeans either burned to death or slaughtered as they fled, horseless and afoot, through the one gateway with 25 steps.

From the brief description of the drainage given above, it is at once evident that we are dealing with a special topography not corresponding in any way with that of the continental divide as recognized in the Rocky Mountains of North America or the Andes of South America.

According to Griscom:[6]

Geologically Central America is not a part of North or South America, but is a third element between the two. The folds in the earth's crust which form the Andes and the western ranges of North America are not continued in Central America, where the strata are folded from west to east.

By far the greater part of Central America and Mexico is covered by Cretaceous and Tertiary deposits, both sedimentary and volcanic. But here and there from southern Oaxaca to Northern Honduras, and particularly in Guatemala, Palaeozoic granites and schists, overlaid by limestones containing Carboniferous fossils, are known to occur and below these is a considerable thickness of beds supposed to be Silurian. Wherever the strike has been observed, it is approximately from west to east. Sapper has definitely identified Palaeozoic rocks in the *Altos* (Highlands), of Huehuetenango and Quiché, and the ranges running east in Vera Paz. . . .

The great volcanoes of Mexico and Central America began their eruptions towards the close of the Cretaceous period, and vulcanism was widespread during the Eocene and possibly the Oligocene. Hill believes that the greater mass of the present volcanic heights was piled up before the Pliocene, and the present craters are feeble and expiring phenomena. The extent of the volcanic deposits is very great and most of the southern half of the *Altos* is buried under these to a maximum thickness of 10,000 to 12,000 feet, entirely concealing the original structure of the ground.

In fact, there is evidence that the plains, no matter how dissected by ravines, which surround Huehuetenango, Santa Cruz Quiché, Chimaltenango, Quetzaltenango, Guatemala City and Salamá, to mention only a few places which I have personally seen, are really enormous deposits of ash filling deeper and older valleys acting as catch basins. The ash itself is often white or chrome; locally it is called *talpetate;* it packs tightly, but is easily eroded by running water; these two qualities explain the occurrence of the extremely precipitous side-walls found in almost all the *barrancas;* the *talpetate,* though easily eroded, is nevertheless extremely cohesive; it has little tendency to slide; consequently the *barranca* walls, when not vertical, are pitched at a slope that would not otherwise be possible. The

[5] This narrow neck of land across the ravine is still in place. The quotation is from S. J. Mackie, "Documents and Narratives concerning the discovery and conquest of Latin America," Publication No. 3, Cortés Society, New York. 1924.

[6] L. Griscom, Amer. Museum Natural History, *Bul.*, 64: 24, 1932.

extent of the dissection of these ash catch-basin plains can not be appreciated by a man standing on the plain itself, but it is extremely impressive when seen from a mountain or an aeroplane. The dissection is so great that it offers serious impediments to travel. Piercing this blanket of volcanic deposit, older formations, such as the Cuchumatanes, protrude here and there. It is a short, ten-day visit to these mountains which I shall describe.

Let me state at once that our itinerary was most vaguely outlined. Our plan was to ride from Sacapulas to Huehuetenango and from the latter place as far into the Cuchumatanes as our time permitted. We could find no one in Guatemala City who could give us specific information as to a choice of route or other information. Although this high mountain country is by no means uninhabited, it is seldom visited and then only by native commercial travelers either on foot or horseback, with none of whom could we establish contact before our departure. So far as our party was concerned, therefore, we were visiting country about which we had only the most rudimentary foreknowledge.[7]

We left Guatemala City by automobile on March 31, 1934, for Santo Tomás Chichicastenango, a picturesque Indian village in the department of El Quiché. Here we put up at Alfred Clark's comfortable Mayan Inn, and proceeded the next day, two hours and a half, to the village of Sacapulas, on the banks of the Rio Negro. Here we spent the night at the house of Doña Eugenia Fernández, with whom arrangements had previously been made by Mr. Clark to lodge us and to supply us on the following morning with saddle and pack animals.

Our arrival in Sacapulas caused quite a stir, for foreigners seldom visit it, and, I suspect, the riding trousers of the ladies added to the wonderment of the inhabitants; for a woman in the country districts of Guatemala either follows her husband's horse on foot, or if she rides, modestly uses a side-saddle; she would consider riding-trousers more out of place on a woman than we would skirts on a man. Crowds of little boys soon surrounded our 1931 model car and the Ford truck; from their comments I gathered that both of these antiquated vehicles appeared to them as the last word in high speed development. As compared with an ox-cart, the comparison is valid; and we were already in territory where even the ox-cart is seldom used, owing to the lack of wagon roads, while just across the river all traffic is necessarily by horse or on foot.

We found Sacapulas to be a neat white-washed adobe village, the buildings mostly with tiled roofs, for the valley of the Rio Negro is a distinctly dry, almost desert country. Although its altitude of 4,500 feet[8] above sea-level is only 500 feet less than that of Guatemala City, nevertheless it is hot during the day and cold at night. These conditions are those commonly found in Guatemala in the high interior valleys lying south of a cordillera; their aridity is due to the heavy precipitation falling on the northern slopes of the cordillera, where the hot, moist trade-winds blowing from the sector between northeast and southeast over the lowlands of the Yucatan Peninsula meet high elevations and are rapidly chilled, precipitating excess moisture. Although the heaviest precipitation falls, as I have said, on the northern slopes, some is also deposited around mountain tops; the result is an arid valley lying at the base of better-watered heights. Consequently, con-

[7] See O. La Farge and D. Byers, "The Year-Bearer's People." Pub. No. 3. Middle Am. Res. Series. Tulane: New Orleans, 1931. F. Blom and O. La Farge, "Tribes and Temples." Tulane Univ., New Orleans, 1926. Interesting collateral reading is offered by T. Gage, "The English American. A new survey of the West Indies, 1648," edited by A. P. Newton, London, 1928.

[8] L. Griscom, *op. cit.*, p. 421.

siderable streams may flow through relative desert. The spots of lush vegetation wherever water is available are in strong contrast to the desert vegetation surrounding them. If these contrasts in one valley are sharp[9] the contrasts between two valleys are even sharper; it may truthfully be said that each valley forms a little world of its own; its rainfall and temperature, and consequently its flora, are mainly dependent upon purely local topography, such as the relative positions and altitudes of surrounding peaks, the elevation of the valley above sea-level, and its degree of protection from the humid winds blowing in over a hot coastal plain.

My diary reads:

> Left Chichicastenango at 2:05 for Sacapulas. The country is extremely mountainous, but the very abrupt *barrancas* (ravines) between Los Encuentros and Chichicastenango are absent. The foothills only of the Cuchumatanes tower wall-like across the northern horizon. From the flat, basin-like plain of Santa Cruz Quiché, the topography has changed to steep mountains with rounded contours covered with sparse spindly pine and twisted oak. Occasional organ cactus at the lower levels. Grass burnt brown (this time of the year is the dry season). The road is excellent though very narrow and winding, with plenty of grades that require shifting to first speed downhill as well as up. Arrived Sacapulas 4:45 P.M.

There is not much to say about Sacapulas itself; perhaps we should mention that Thomas Gage passed through it just prior to 1648, on his journey to Guatemala from Mexico.[10] Gage says:

> The town, though it be not in the general very rich, yet there are some Indian merchants who trade about the country and especially to Suchitipequez,[11] where is the chief store of *cacao*, and thereby some of this town of Sacapula have enriched themselves; the rest of the people trade in pots and pans, which they make of an earth there fit for the purpose. But the principal merchandise of this place is salt, which they gather in the morning from the ground that lieth near the river. The air is hot, by reason that the town standeth low and compassed with high hills on every side. Besides many good fruits which are here, there are dates as good as those that come from Barbary.

Five days later, after Gage had "wearied out the weariness which I brought in my bones from the Cuchumatanes"[12] he continued on his journey to Guatemala City.

Doña Eugenia allotted us two rooms with rough tile floors upon which to spread our bedding, and after we had arranged our dunnage, I interviewed the mule man. He informed me that a saddle horse could make Huehuetenango in one day, but that with pack animals it would be preferable to sleep at Aguacatan, only six hours distant, slow riding. After various other arrangements had been concluded, I set the breakfast hour for four next morning and we all turned in.

The next morning (April 2) all hands were roused shortly before four, breakfast was eaten, and to my astonishment, horses and mules were saddled and ready. After the usual delays incident to packing on the first morning, we got

[9] An idea of the extent of this contrast is afforded by a comparison between Quiriguá and Zacapa, both on the Motagua River and only 25 miles apart. From *Revista Agricola*, Vol. XIII, No. 2, pp. 123–26, the following is obtained: Quiriguá: elev. 225 feet; annual rainfall, 2083 mm, vegetation, formerly a tropical jungle, now banana plantations. Zacapa: elev. 603 feet; annual rainfall, 731 mm, vegetation, mimosa and cactus; L. Griscom, *op. cit.*, p. 19, gives rough rainfall figures as follows: Caribbean Lowlands and northerly slopes of the mountains in Alta Vera Paz, 180–200 inches; Motagua Valley near Zacapa, 6 inches; Salamá (elevation 3,000 feet), 26.5 inches; Guatemala City (elevation 5,000 feet), 55.0 inches; and Pacific Slope, 80.0 inches. The same author (pp. 19–20) illustrates the extreme localization of conditions governing rainfall by describing the meteorological phenomena over Lake Atitlán.

[10] T. Gage, "The English-America. A New Survey of the West Indies, 1648," p. 177, 1928 ed.

[11] The present name of a department on the Pacific coast of Guatemala southwest of Lake Atitlán.

[12] T. Gage, *op. cit.*, p. 177.

off from Sacapulas at 7:15, crossed the Rio Negro on a substantial modern bridge, and turned westward towards Aguacatan, following the Rio Negro for a short distance only before crossing a ridge into the valley of the Rio Blanco. We crossed the Rio Blanco also by bridge at a small collection of *ranchos*, and immediately started a long and extremely steep ascent—the Cuesta del Aguila. This ascent consumed more than an hour, as the animals had to be breathed at short intervals, and packs had to be adjusted several times. When we arrived at the top, an open, grassy meadow among pine and oak, a warm sun and a cool breeze invited us for a rest and lunch. As we had already been six hours on the road, traveling about two and a half to three miles an hour (except on the Cuesta), I supposed we must be at least near Aguacatán.

After a forty-five-minute stop we continued, following along the top of a high and very steep-sided ridge from which we could see the Rio Negro on the south and the Rio Blanco on the north. The scenery was magnificent and the road suitable for wagons or automobiles, had they been able to get on it; unfortunately there was no connection at either end; the Cuesta del Aguila had offered difficulties even to the pack mules.

The ridge we followed mounted higher and higher to roughly 5,500 feet; it led us to a flat-topped table-land, with occasional groves of pine and oak, but mostly open grass land. It was but a sparesly occupied region, however; a few flocks of sheep were met with, fewer cattle and still fewer horses. The sheep were always herded, often by small children, occasionally by a woman. On a particularly smooth and grassy plain called the Llano del Coyote we noted six small artificial mounds crowning six widely separated rounded hills. A few houses on this plain, grouped near seepages of water, suggested that the lack of *ranchos* elsewhere might be due to a scarcity of springs. The few houses we passed were all rectangular, with tiled roof and adobe walls plastered white, built on platforms of earth (often with retaining walls of rock) and having a front porch supported by four wooden joists.

Almost all of the houses were accompanied by crude corrals, and had near them elevated, wooden platforms roofed over with thatch; the latter were 8–12 feet high and our guide informed us that they were used as a storage place for corn on the cob in order to protect it from rodents (probably field-mice or ground-squirrels).

It was now approaching three o'clock and our party had had enough for the first day out; our guide assured us, as he had been doing all along, that Aguacatán was "muy cerca." Nothing more definite could we get out of him; since arriving on top of the table-land, the terrain sloped gradually down to the northwesterly; in the blue distance rose the steep slopes of the Cuchumatanes. Somewhere between us and them lay the valley of the Rio Blanco, and in it, Aguacatán; but the valley was not visible. At the present gradient, we would have to ride miles and miles to get to the bottom; this was most annoying to contemplate as we jogged monotonously along at a slow trot, but I encouraged myself by saying that at any moment we would probably come to a sheer drop and see Aguacatán[13] lying directly beneath us.

Although the drop into the valley was not a sheer one, yet it was very precipitous, and deeply dissected with ravines. The pack-train slid and slithered down the slope in great clouds of white dust, plumped into a shallow river-bed full of boulders, called the Rio Seco, and crossed a broad flood-plain to Aguacatán. In response to my enquiries at

[13] Elevation, according to Urrutia's map, 1924, 1,500 m.

the only inn, a boy was despatched for the owner, Señor don Gonzalo Ríos, to whom I had a letter of introduction. Upon his arrival, he offered us the use of his unoccupied house just outside the town for the night, an offer we were glad to accept; so we rode through town and came out on to an irrigated and cultivated plain on the north side. It was a refreshing change from the glare through which we had been riding, and the little house. surrounded by irrigation ditches and gardens, was in a real oasis. Less than a hundred yards away a great spring gushed from the foot of a hill; it was the source of the Rio San Juan, which is a stream flowing into the Rio Blanco. The spring measured more than twelve feet in diameter, and the icy water poured from it with a roar.

It was 3:15 when we entered Aguacatán; by the time we had unpacked the mules at Señor Ríos' house, it was all of an hour later. So after a hearty meal and a wash, we turned in at sundown. In these latitudes night falls quickly, with but a short twilight interval between day and dark. By seven o'clock every one was asleep.

The next morning we awoke refreshed, and having very definite information from Señor Ríos, an intelligent man, that a pack-train could reach Huehuetenango in less than five hours, we ate a leisurely breakfast and then rode out to the ruins of Chalchitan, or Pueblo Nuevo. These are a collection of mounds arranged in the typical Maya formation —temple-pyramids grouped around plazas—lying on the valley floor about a mile east of town.[14] Very little stone-work was visible; whatever may have existed probably had been used in building the modern town.[15] There are other ruins, not on the valley but on a height, called to-day Pueblo Viejo; according to Recinos, Xolchun. The same author also mentions other ruins called Chichun which he suggests served as a defense-works for Chalchitan.[16, 17] We did not visit either of these sites. The ruins are said to belong to the Mam division;[18] the language spoken in the modern town is a special dialect known as Aguacateca.

We returned to town, met our pack animals in front of the *alcaldia;* in the plaza on which it faces is a large stone trough, hollowed out of one piece of stone, said to come from Chalchitan.[19]

We bade good-bye to Señor Ríos with many thanks for his hospitality and proceeded over a much better road than yesterday's to Huehuetenango, traversing less arid country covered chiefly with scrubby oak and pine, with fewer steep slopes and consequently fewer extensive views. The journey took four hours and three quarters, and we rode into town on anything but jaded beasts; in fact, we were relieved at not meeting automobiles, for our Sacapulas animals were by no means used to them, and we were glad to see the street doors of the Hotel Galvez thrown wide when they heard the clatter of our animals on the cobbled street. We rode, with a tremendous ringing of iron shoes on stone, right through the front door of the hotel across the patio, and into the second court-yard. It is a more dramatic way

[14] Mapped by K. Sapper, "Das Nordliche Mittel-Amerika nebst einem Ausflug nach dem Hochland von Anahuac," 1897; mentioned in F. S. Cruz, *Proceedings*, Pan-American Science Cong., Vol. 1, Sec. 1, Anthrop., pp. 220–24, 1917; A. and C. Villacorta, "Arqueología Guatemalteca," Guatemala, 1927; Recinos, "Monografia del departamento de Huehuetenango," pp. 166, 245 *et seq.*, 1913.

[15] True of the ruins of Tayasal in the Department of the Petén (the church of the modern, nearby town of Flores has a carved stela built into the north wall); also true of the ruins of Utatlán, near modern Santa Cruz Quiché.

[16] A. Recinos, "Monografia del departamento de Huehuetenango," p. 248, 1913.

[17] Karl Sapper, *op. cit.*, 1925.

[18] A. and C. Villacorta, "Arqueología Guatemalteca," p. 145, Guatemala, 1927.

[19] Illustrated in Recinos, *op. cit.*, p. 249. It measures 1.12 meters high and 1 meter wide. (Length not given, but less than 2 meters.)

of entering a hotel than merely handing your bag to a liveried bell-hop.

Huehuetenango is the capital of the department of the same name; it lies at the very foot of the Cuchumatanes at an elevation of 6,800 feet.[20] Any one less hardy than the descendants of the Spanish Conquistadores would build fireplaces in the houses, for the nights are cold. As it is, the only way to keep warm before retiring is to drink a fiery liquid called *comiteco;* this is a superior brand of sugar rum made in Comitán, Mexico, and is affectionately referred to as *alambique al alambre espigado*—distilled barbed wire.

The proprietor of the hotel, Señor Rodolfo Apel, had already arranged for animals to replace those from Sacapulas; so that beyond a few errands there was little to do. I called at the *Jefatura Política* to present my credentials to the governor, Señor Velázquez, and to receive from him a letter to the departmental authorities, both civil and military, ordering them to lend our party all assistance. Travel in this region should not be undertaken without official identifying documents obtained locally.

On April 5, therefore, we rose at five, breakfasted, and after loading and despatching the mules, took a car to the neighboring town of Chiantla.

This town lies about a league from the capital and at the very base of the Cuchumatanes. It is chiefly famous today for two annual fairs, at which there is a very large market for livestock, and a church housing the miraculous image of the Virgin of Candelaria. Gage mentions this image as follows: "I had been informed of a strange picture of Our Lady which was amongst these mountains in a little town of Indians called Chiantla . . . belonging unto Mercenarian friars, who doubtless would not be able to subsist in so poor a place had they not invented that loadstone of their picture of Mary, and cried it up for miraculous."[21] Recinos gives the population of Chiantla as 2,000, and that of the whole municipio as 10,000.[22]

Here our pack-animals joined us—we had planned to see the miracuolus Virgin, but were unable to do so at this early hour—and after minor adjustments to packs and saddles, we started up the famed Ventoso Pass (cerca 11,000 feet) on the old road between Guatemala and Mexico. The ascent from Chiantla is roughly 5,000 feet, which we made in four and a half hours to the summit. For the most part the trail was excellent, though there were steep stretches of loose rock (mostly during the first two hours) and, near the summit, some passages too narrow for mule-trains going in opposite directions to pass. These passages, however, were short, and owing to the winding nature of the trail (which permitted a view of approaching pack-trains, of which there were many), little time was lost. One small village of huts, Las Cordilleras, was passed between Chiantla and the summit; it exists as a resting-place for muleteers. The vista was most impressive. Against the sky could be seen the whole line of volcanoes which stretch along the Pacific border of the tableland from the Mexican boundary south to the Volcan de Agua, towering above Antigua, Guatemala.

Near the summit of the pass was a cross; beyond this the notch through the mountains narrowed. It was a bleak and windy spot, with a few gnarled trees; beyond this gateway the landscape opened onto rolling, grassy and treeless plains, interrupted here and there with gently rounded, sparsely forested hills. These grassy plains would

[20] L. Griscom, *op. cit.*, p. 418.

[21] T. Gage, *op. cit.*, pp. 174–5; see also O. La Farge and D. Byers, "The Year-Bearer's People." Pub. No. 3, Middle Am. Res. Series. Tulane: New Orleans, 1931.

[22] A. Recinos, *op. cit.*, p. 171.

have seemed to afford excellent pasturage, but we met with few sheep and still fewer cattle. I can only suggest the lack of utilization of this land for grazing purposes as due to a combination of three factors: a prolonged annual dry season, a sparse population and no adequate communication with an outside market. The very occasional, windowless, mud-and-log huts scattered here and there only emphasized the primeval silence of these wind-swept mountain tops.

We stopped for lunch beyond the pass near an unoccupied hut, under whose lee we sought shelter from the bite of the wind, by now unpleasantly sharp. Masses of black thunder heads piling on us from the northeast, however, warned us that we had better try to reach a lower altitude, so we pushed on. The trail, after crossing open, more or less rolling, plains, soon entered a narrow valley lying between two long ridges stretching apparently endlessly to the north. Here the vegetation was predominantly gnarled cedar, majestic cypress and other evergreen trees, with a silvery-barked, gray-green deciduous tree resembling aspen; moss or lichen covered the ground or hung from the branches. In the metallic light reflected from the approaching storm-clouds our surroundings took on the appearance of stage scenery rather than an actual landscape. At 2 o'clock the storm broke; at first a chilling, drenching rain, but this soon turned to hailstones as large as pigeon-eggs. These were a relief from the rain, but the hail, increasing in intensity, soon beat upon us with such violence that it became painful to expose our hands holding the reins. In an incredibly short time the ground was covered, and our progress was nearly halted because the hailstones balled up under the animal's feet. The danger of a fall was therefore added to our other discomforts, so I dismounted and called back that it would not only be safer and warmer to get off and walk, but that we would also make better time. Fortunately it was only a half hour further to an abrupt drop into a long, narrow valley leading down 2,500 feet to the little Indian town of Todos Santos. Hail had not fallen here, so we re-mounted and rode along beside a turbulent stream, flowing between steep pine-clad slopes. Primitive huts began to appear on either hand, usually perched in little hillside clearings. None of these huts appeared to be occupied and we marvelled why any one would bother to build such very crude constructions, until our head *arriero* volunteered the information that they were only occupied during the planting or harvesting of the potato crop. During the rest of the year the Indians reside in their houses in Todos Santos.

We approached Todos Santos[23] down a winding lane, flanked on either side by high stone walls. The lane, perhaps because of the stone walls, was reminiscent of a country road in New England, but here the resemblance ended, for the steep-sided spur stretching on our right from the main mountain-mass was so sheer that in many places it was palisaded; great talus slopes extended up the face of the cliffs. It was eloquent explanation for the trails in this region running north and south, following the topography. I now understood clearly why all my suggestions that we plan our route so as to make a great circle back to Sacapulas invariably met with an emphatic "That is impossible!" Parallel series of these great spurs extending northward from the main mass of the Cuchumatanes prevent all east-west travel.

Our reception in Todos Santos was a royal one. As the thatched huts clustered closer, the throb of a marimba be-

[23] Elevation, 2,470 meters; population, 5,000. A. Recinos, *op. cit.*, p. 187.

came increasingly audible; children scampered to the safety of their houses to view the foreigners as they passed; men and women peered through doors or sashless windows. When we entered the grassy *plazuela,* the marimba boomed from the porch of the *municipalidad* and it was evident that the more important men of the town had assembled to welcome us. Nothing could have been more picturesque than this mountain-village square, with its thatched houses, cradled in the narrow valley, and the principales lined up in their extraordinary Todos Santos costume—loose homespun cotton trousers, white with broad red bands, worn under a split over-trouser of natural black wool. Their *capishays,* or tunics, were also of natural black wool; the usual head-dress was a hand-made hat of straw, in some cases worn over a red headkerchief; the latter was the only imported article of dress.

Our cavalcade was officially met by don Luis Rivas, secretary of the Municipalidad,[24] who presented us to the *alcaldes* and other principal men. The latter's knowledge of Spanish was just sufficient to give us welcome in a singsong falsetto; nevertheless the welcome was a cordial one, for we were the first visitors in a year and the first Europeans, probably, since La Farge and Byers[25] seven years before.

The school-house, a great cavern of a room adjoining the *municipalidad,* had been freshly strewn with pine needles in honor of our arrival, and thither we were led by the whole reception committee, augmented by a great crowd of the curious. All of the villagers who were not absent at work on some *finca*[26] on the coast, soon gathered in the room to watch us. This made unpacking a bit of a problem and getting out of our damp clothes an impossibility. However, the whole atmosphere was so friendly that it called for a demonstration of appreciation on our part; so I asked don Luis to send out for aguardiente. A half-gallon carafe, price 50 cents, promptly made its appearance, accompanied by two or three small glasses, somewhat chipped around the rim, and looking as though countless fillings had more or less corroded their inner surfaces. At first I deemed it wise to retain possession of the carafe, thus insuring each and every man one drink, and no more. This precaution was unnecessary, for the *alcalde primero* assumed the rôle of master of ceremonies and saw to it that there were no repeaters until all had been served. The remainder was then polished off by ourselves and the *principales.* Aguardiente is a fiery beverage, but even so we were most grateful for our ration after the rain and cold in the pass.

Finally darkness began to fall and the crowd dispersed. By shooing the urchins out of the room, sufficient privacy was vouchsafed us (aided by the dim light in far corners) to slip into dry clothes. Don Luis informed us that supper had been prepared in an adjoining house, and that he would be honored if we would eat with him. The piece de resistance was venison—a doe, shot that day, to judge by the head and hide hanging from a beam just beyond us. We threw the bones to the dogs under the table.

Next morning, after a night on the school-house floor which required not only all our blankets but sweaters as well, we climbed a spur to some ruins about fifteen minutes' walk from the center of the village, and on the same side of the valley. As La Farge and Byers reported a collection of small

[24] A Spanish-speaking secretary is appointed for towns predominantly Indian, where little or no Spanish is spoken. Such men are usually intelligent *ladinos;* among their duties is included that of liaison-officer between the community and the central government.

[25] 1927.

[26] Plantation.

mounds near Todos Santos called Cu Manchón, we supposed this to be the same ruin, calling it thus to some of the Indians who joined us at the ruins a little later. They informed us, however, that Cu Manchón was on the other side of the valley across the river, and that this ruin was Tucumanchú.[27] Only further investigation would reveal which is correct; the plan of the ruin we visited is the same as that of the Cu Manchón ruin shown in the "Year-bearer's People."[28] I climbed to the tops of all the mounds before our Indian friends joined us. Mound A was crowned by a *quemador*—a place where incense is burnt—but I saw no remains of the stucco figure in the round mentioned in the work cited; no doubt it had disintegrated. Fortunately I had made my little reconnaissance before the Indians came up, for one among them volunteered the information that any person climbing to the top of that particular mound would die—a statement I interpreted as an oblique request not to ascend the mound, and one which I felt would be untactful to disregard in their presence. There was also a small altar in the plaza by this mound which showed the ash and charcoal of freshly burnt wood and recently picked offerings of flowers.

We then returned to town, meeting as we did so, a procession carrying a saint. Music was supplied by a *tunkul*,[29] fife and violin. The procession proceeded to the ruins and there we were told prayers would be offered for rain.

After a noon lunch we got off for San Martín Cuchumatán, four and a half hours' journey distant. The trail had now expanded into a fine lane winding down the broadening valley. The great spurs forming either wall of this valley became less and less precipitous, and enclosed between them a vista northward over ever lower and flatter land, until the far horizon showed a dead level skyline blurred with the haze of smoke from *milpa* burnings.[30] We were looking down on the hot jungle in the State of Chiapas, Mexico, geologically forming the base of the Peninsula of Yucatán. Our road ran through a region that was extensively deforested, for even extremely steep slopes had been put under cultivation by an increasingly dense population. As we descended, the temperature rose and the vegetation became more lush.

About four-thirty we drew into the little settlement of San Martín Cuchumatan; Recinos[31] gives its population as 400, counting both Indians and Ladinos, and its elevation as 1860 meters, compared with 2470 meters at Todos Santos. There was nothing particularly attractive about this town except the view; even the church, whose bells bore the date 1784, was almost in ruins; across the grassy common in front of it and hidden in a *cafetal*[32] was a good-sized Maya mound. On a spur about a mile to the north of the *municipalidad* is a group of mounds called Tilajyon and reported in the "Year-Bearer's People."[33] We did not visit the site.

The *alcalde*, Raimundo Herrera, gave us the school-room for our night's lodging. Next morning when we were packing to leave, he drew our attention to some empty tins which we were leaving behind; when we said we did not want them, he immediately asked if he could take them, to use as cups. I mention the incident to indicate how little contact

[27] A. Recinos, *op. cit.*, 187, refers to ruins south of Todos Santos under the name Tecum-Manchu (House of Tecum).

[28] O. La Farge and D. Byers, *op. cit.*, fig. 74, *a*, *b*, p. 238.

[29] Native drum made from a hollowed log.

[30] A *milpa* is a clearing in the forest for planting corn; it is burned to destroy the felled timber before planting.

[31] A. Recinos, *op. cit.*, p. 185.

[32] Coffee plantation.

[33] O. La Farge and D. Byers, *op. cit.*, pp. 19, 232–3. Map, 233.

this region has with the industrial world with which we are familiar.

After a much warmer night than we passed at the higher elevation of Todos Santos, we breakfasted at six and set off for Jacaltenango by way of Concepción; we did not visit the latter town, as it is located on a spur off the main road. The journey was only four hours, 35 minutes, all down grade, the road crossing but one divide, from the drainage of the Rio Chanjon to that of the Rio Azul. The country was much more open and rolling, affording magnificent views. The rise in temperature as we approached Jacaltenango (altitude 1,400 meters)[34] was noticeable, as was the complete deforestation of the land. Recinos gives Jacaltenango an estimated population of 4,000. La Farge and Byers describe the inhabitants as "obviously of mixed origin; some of the Indians have light brown hair and blue eyes; the Indian cast of their faces is weakened by European blood. The very strongly mixed type among the men tends to be gangling in build and shifty-looking." Their costume is usually home-made trousers and shirt of European type; the costume of the women, a white cotton blouse, or *huipil,* with embroidery around the neck, worn outside the skirt, is fundamentally Indian. Their skirts, a plaid design on a blue or red background, are made in Quezaltenango; like other Indian skirts, they consist of a single piece of material wrapped tightly about the hips, and held in place either by a woven belt or by the loose corner being tucked under. The clothes of both the men and the women we saw were for the most part ragged.[35]

Jacaltenango itself impresses one as a slovenly, sprawling town without any of the neatness or picturesqueness so often characteristic of an Indian pueblo. Both the pole-walls of the thatched huts and the pole-fences surrounding them were in a state of bad repair. Children were often seen without a stitch to cover them and many in a state no cleaner than the animals living with them; the dogs were scrawny and mangy. The dirt streets through which we rode were full of rocks and uncared for, without any attempt at drainage. One felt that they would have been full of refuse were it not for an efficient scavenger department formed by dogs, pigs and buzzards. At the far end of town we reached the plaza, more like a large common, on which faced the church, the *juzgado municipal,* the school-house and several better-class houses; but there was nothing about it reminiscent of the usual Latin-America plaza, which generally shows at least an attempt at formalization — fountain, band-stand, flowers, benches. Here there was nothing but a big, grassy square without even the indication of streets or sidewalks.

We stopped in front of the *municipalidad,* and I dismounted to present my letters from the *jefe politico.* Before I entered I was careful to have my coat on, my hat off, and to tie my machete to the saddle, for one may not present oneself with arms of any description. The *secretario* greeted me cordially, but while I was talking to him, I felt something tugging at my foot; an *alguazil*[36] was removing my spur. Quite at a loss to know just what this meant—whether it was a custom of courtesy on their part or an infraction of etiquette on mine—I continued the conversation. When the *alguazil* had removed one spur, I presented my other foot; when he had removed both spurs, he picked up his stave of office, crossed the room and deposited the spurs on the *alcalde's* desk; I then realized that there would be a fine for their return. However, it

[34] A. Recinos, *op. cit.*, p. 195.

[35] Perhaps we should add that the world-wide depression has its effect here as elsewhere.

[36] Employé of the municipality, serving by rotation.

did not seem to be an opportune time to make any protest. By virtue of the letter we were assigned, as usual, the school-house, and *alguazils* were despatched to see that our needs were supplied, in the way of firewood for cooking and fodder for the animals. During the process of unpacking, I forgot about the spurs, and after lunch the sudden change to this lower altitude, sent us all to our bedding rolls for a siesta. I was called from this later by an *alguazil's* informing me that the *alcalde* wished to see me. I then remembered the spurs, and prepared myself to pay a small fine with the best grace possible for my unwitting misdemeanor. But I was not prepared for what took place; in the presence of the *alcalde* and another official, the *secretario,* obviously under orders, read me a long lecture on the lack of respect I had shown duly-constituted authority. Although this made my gorge rise, I refrained from comment until a pause in the *secretario's* speech; then I respectfully drew their attention to the fact that I had put on my jacket, removed my hat, and left my machete before entering, and that my failure to remove my spurs was due entirely to my ignorance of such a requirement, and not to any intentional slight on my part. The spurs were then returned to me without fine—"in view of the letter which I bore from the *jefe politico."* Jacaltenango gave us the only unfriendly reception that we were to receive during our journey; even the forage and firewood was supplied grudgingly, although the price asked, and paid, was more than the regular one.

Next morning we were up before dawn and glad to shake the dust of this inhospitable town from our feet. We had now reached our furthest north, and from here our road led us back by a different route to Huehuetenango; it would take us westerly across spur ranges to San Antonio Huista, and thence across more spurs to San Pedro Necta, on the Rio Nillá, just above its confluence with the Rio Selegua; the latter stream arises in the environs of Huehuetenango. However, the trail did not follow up the Selegua Valley, but out across boldly mountainous country through Santiago Chimaltenango, San Juan Atitlán, Santa Isabel and San Sebastián, approaching Huehuetenango from the northwest.

Upon leaving Jacaltenango the road immediately started the ascent of a steep ridge, dropping just as suddenly from the crest into the neat *pueblo* of San Antonio Huista. Here in a picturesque and anciently cobbled plaza a colorful market was in full swing; our cavalcade turned into it, and of course the pack-mules followed. A sergeant from the *comandancia* immediately presented himself and our guide Eugenio whispered to me: "We cannot let the animals stand here." As we had attracted a good deal of attention, he advised me showing my letter. The others being only too willing to delay in the market, I dismounted and fished out the letter; although the sergeant was more than civil, I had a distinct impression that five foreigners at once had completely paralyzed his mental processes. Unable to cope with what was no situation at all, and unable to read (for a young recruit in his 'teens had been summoned to read haltingly the contents of the letter), he decided that nothing would meet the occasion short of sending for the *comandante militar.* As it was only nine o'clock of a Sunday morning, the *comandante* was no doubt leisurely arising; but sent for he had to be. Ruth Reeves began sketching and was promptly surrounded by a gaping multitude; my wife and Honor Spingarn were lost among the fruits and textiles in the market; a plot back of the *comandancia* was assigned to us to park our

animals, while I sat on the *corredor*[37] of the *comandancia* chatting with the sergeant. I felt that just so long as I made no attempt to leave, the sergeant was reassured of my legitimate right to be alive and at large. The *comandante* then arrived, in trig military uniform, and immediately offered us any assistance of which we stood in need; when we assured him that we were merely "*de paseo*" he stamped our letter and bade us a most cordial God-speed.

Knowing that prolonged delays with a pack-train are fatal, I tried to get every one under way immediately. But Eugenio had gone off to buy bread, and the others were lost in the beauties of the plaza market. So I pushed on ahead, telling everybody to hurry. In half an hour the outfit caught up; we crossed the River Huista on a covered bridge and then followed the sparkling little river upstream; at noon we unloaded and picnicked on its banks, taking a swim in its none-too-warm waters. The vegetation was open forest, mostly oak, with grass beneath; on the higher slopes, pines. After lunch, the trail led first up and then down over a series of razor-back ridges, with extremely steep gradients; about 3:30 P.M. these ridges gave place to very steep, broken mountains; at 4:30 we dropped into a cup-shaped valley. Here we passed a tumble-down *rancho* and I asked the man sitting on the *corredor* if he could sell us fodder for the animals; he had none, nor did he or our guide know how much further it was to Chichim, where we had planned to spend the night. I was tempted to stop, as it was late, but after a consultation, pushed on, chiefly because there was no fodder and not a level ell of ground on which to spread our bed-rolls. The country was so well-watered that I felt sure we could find a good camping place ahead.

But the trail led on to a great ridge with no streams, no single level spot, no grass for the animals, and no houses. We rode along this ridge, marveling at the scenery (and where the ridge was going to lead us), until 5:30, when we came upon two old grass-thatched lean-tos with ashes from cooking fires in front of them; and here I announced that, water or no water, we would spend the night, as darkness would soon be falling. Examination revealed huts not too far down the side of a valley on our right, so I sent Eugenio to investigate; he reported water and a pasture belonging to a *finca,* but there was no *mayordomo* to give us permission to enter. However, we rode down; the Indian *mozos* would not sell us firewood and one said we could not stay without permission, but by this time the packs were off and we were all scrambling to find the levellest spots on which to spread our bedding-rolls. We gathered some dead wood and threw together a hasty supper; the *mayordomo* then arrived and proved most amiable over a cup of chocolate. He said the *finca* was called Ixnul, and that we were very welcome, but please to stake out the animals lest they get into his foot-high corn. When darkness fell, we found ourselves looking down into a fairy bowl with a myriad fires; this was the season for burning *milpas.*[38] Long ragged lines of fire burned slowly up the slopes, looking like gigantic glow-worms; smoldering stumps dotted the landscape here and there with a dull glow, and occasionally a dead tree, burnt through at the base, would fall with a reverberating crash and a galaxy of sparks. Thirty minutes after dark we were all sound asleep.

The chill at this high altitude aroused us before dawn; we breakfasted at the first light, and started over a much narrower and rockier trail, with even

[37] Porch.

[38] In Guatemala, corn is cultivated by the *milpa* system; land is cleared at the beginning of the dry season, the felled bush allowed to dry until just before the rains, when it is burnt, and the seed planted.

steeper grades than the day before. As we proceeded, more or less to the southerly, each valley became increasingly arid. The mountains, although just as high and steep, exhibited fewer rocky crags; the long, often palisaded, ridges of the Todos Santos region were replaced by a tumbled terrain—hills jumbled every which way rather than in long parallel rows. Before we completed the ascent to the height of the pass the road ran through majestic groves of enormous *ciprés*.[39] Judging by the size of these trees, the mossy forest-floor and the presence of anciently fallen trunks of the same size, I assumed that these now scattered groves were remnants of a primeval forest which had once covered these slopes. If my memory serves me correctly, such groves only occurred on the northerly slopes, presumably because it would be on them that the greatest precipitation fell. The countryside, though large areas had been deforested for *milpas*, was by no means thickly populated.

Once through the pass the road dropped precipitously, through scraggy, second-growth oak for the most part, into the Selegua drainage. For a long time during this descent, we could see the town of San Pedro Necta almost directly beneath us; the final descent to it was by far the narrowest and steepest we had yet encountered, the animals swinging head and neck over precipitous slopes at every zigzag. On the opposite side of the valley was a great half-dome presenting to our view a true precipice at least a thousand feet high. As I noted afterwards from below, the road here followed down one side of a hanging valley that debouched above the valley of the Rio Nillá.[40]

At noon we arrived on the outskirts of San Pedro Necta, clattering over the old Spanish cobbles direct to the *municipalidad*, closed, of course, for the noon hour. Everywhere we saw neatly painted stone-and-plaster houses, with fat and well-cared for dogs asleep in the doorways or barking a friendly welcome. Within a few minutes of unloading our packs the *primer alcalde* arrived, with a courteous "Señor, en que puedo servirle?" In five minutes he had sent for a pint of aguardiente, ordered the school-room swept out, and sent off a boy with instructions to a private house to prepare us luncheon. After the first aguardiente, he sent for the *comandante*, because, as I found out later, the school-room was not good enough for us; we were then given an unoccupied room in the *comandancia*, with a *pila*[41] and a latrine. Our comfort was complete; when we were summoned to lunch, we parted from Colonel Heraclio Rodriguez, the *comandante*, and Señor F. Lizardo Díaz, *secretario municipal*, with assurances of our gratitude and a promise to accompany them to some ruins above the town which the latter had just visited the day before for the first time.

A delicious lunch in four courses was no preparation for a climb to the ruins; we managed to stagger up, however, about four o'clock—a terriffic climb it seemed, although we daily rode our animals for eight hours over similar grades. The ruins consisted of a single plaza on a spur, built up from 5 to 7 feet on the northerly side with a slab-stone retaining wall, to make it level. (Fig. 2.) The highest of the seven mounds comprising the group still stood about six feet; most of them showed stone side-walls, of flat slabs like the retaining wall, laid up without mortar and unfaced. Sherds occurred in the cornfield planted there. (Plan, Fig. 2.)

The *secretario* told me that the ruin was called Tepam—undoubtedly a corruption of the Nahuatl *Tecpan*—and volunteered the following history: its original name was Tecpan Usumacinta

[39] Our guide called these trees *ciprés*, cypress.
[40] A confluent of the Selegua.
[41] Water tank.

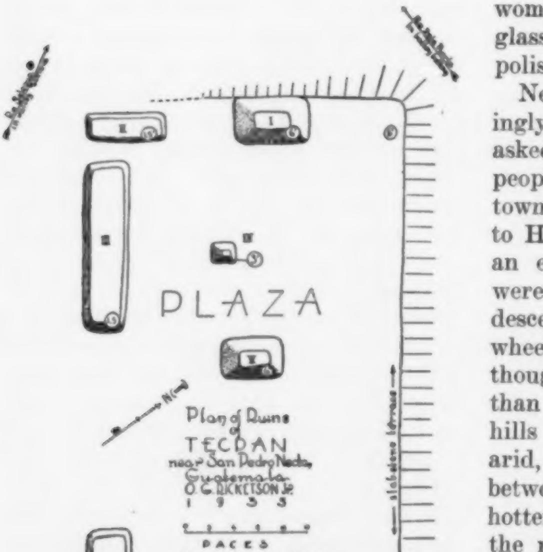

FIG. 2

and its original site was further downstream; the inhabitants belonged to the Mam division of the Maya stock, and had been driven back to this location by an Aztec invasion; the invaders settled on another spur across the river. When the modern town was settled, the half lying on this side of the river was called San Pedro Necta and was Mam; that on the other side was called Santo Domingo Usumacinta and was Aztec. Finally the two settlements united in building one church and to-day it is one town. Such a history should be susceptible of archeological proof.

After examining the ruins we literally slid back to town; the *comandante* graciously showed us some excellent decorative panels done by his son in oil, and at the invitation of the three town officials we repaired to a tiny cantina for aguardiente and lemon juice. The drinks were served by a fine-looking woman; one knew instinctively that the glasses would not only be clean, but polished.

Next morning, April 10th, we willingly paid the two dollars and fifty cents asked for three delicious meals for five people and regretfully left this friendly town for our last night before returning to Huehuetenango. The road here was an excellent one, suitable for wagons were it not for occasional ascents and descents and fords not passable to wheeled vehicles; the country itself, though mountainous, was less rough than that over which we had come, the hills more rounded. It was also more arid, and, although the altitude varied between 4,500 to 5,500 feet, it was much hotter; perhaps the increase in heat was the more noted on account of our descent from higher altitudes, as well as the lack of shade, for the territory is practically deforested. It is densely populated and everywhere cultivated. I noted that many Indian *ranchitos* had a grove of pines planted near them, in a circular formation. Although the planting of pines is in itself easily explained on economic grounds, I know no explanation for planting them in circles.

Our road led us through Santiago Chimaltenango, an unkempt mountain village perched on a spur at an elevation of 2,800 meters,[42] and then San Juan Atitan.[43] Agriculture, some lumbering, (of course without benefit of sawmills, all planks being sawed by hand) and sheep-raising seemed to be the occupations of these remote villages. Since there was nothing of interest to detain us, we continued to Santa Isabel, the smallest *municipio* in the department.[44]

[42] A. Recinos, *op. cit.*, p. 179. Population, 1,500 (Indians).

[43] *Ibid.*, p. 177. Recinos gives "Atitan"; Urrutia's map, "Atitlan." My diary "Atitan." Population, 2,500.

[44] *Ibid.*, p. 177, 12 sq. kilometers. Temperature varies from 10–18 degrees Cent., depending on elevation.

Its small grassy square was surrounded on three sides by very dilapidated stone-and-mortar buildings, thatch-roofed; one of these was all that remained of a small church, still in use, however; another was a long building containing several rooms, used as the *municipalidad* and the school. The third side was open to a view of the valley. The *secretario,* a ladino, could speak Spanish; upon presentation of my letter, he translated it into Mam (I suppose) to the *alcalde,* a dour-looking Indian dressed, as were the other *mayores,* in a natural black wool *capishay* and red head-dress. We were assigned to the school-room, and a fee—eight cents—demanded for its rental.[45] An *alguacil* was despatched to sweep it out; this he did with a leafy branch; seven more men were despatched to bring in as many bundles of cornstalks for our animals, at eight cents the bundle. As I was running low in change, I tried to pay them with two quarters and six pennies, but this they refused to accept as there was no change in the village; so I borrowed enough pennies from the rest of our party to make seven piles of exactly eight cents each. We cooked our dinner over three cents' worth of wood, and sent heaping plates to the *secretario* and the *alcalde;* they had courteously declined our invitation to eat with us. After supper the cold drove us to our bedding rolls early; in fact, it got us chattering out of bed before dawn to make hot coffee and get under way by sun-up.

This was the last day of our trip; the trail led through San Sabastian, whose ancient Mam name Recinos tells us was Toy-hoz[46]—"among the aguacates," a town re-founded on its present site in 1891 following a destructive flood of the Selegua. Although it is located on an automobile road, down bridges prevented our cars from meeting us here. We had telegraphed for them to meet us further along the road, at a place called Chancol. Nothing affords more uninteresting riding than a highway suitable for automobiles; this one, stretching endlessly under a blazing sun, was no exception. It followed the valley of the Selegua through dry, dusty country burnt brown by the drouth of the "dry season." A small Maya plaza surrounded by mounds, between two and one half and three miles out of Chancol, was the only object of interest that we passed.

We reached Chancol at 11:30, but no cars awaited us. So we continued. At 12:10 the mid-day heat was scorching. Some caustic remarks had just been made about the sacredness of appointments in Central America when we heard an automobile horn and were nearly run down by one of our cars; the cars had been held up by repairs to the road where it passed through a defile. We piled off the animals, flung our saddle-bags in the car, and sped on our way (at 15 miles per hour) leaving the truck to await the pack-mules. We had been nine[47] days on horseback and had covered approximately 100 miles (as the crow flies) through a most picturesque and seldom-visited mountain region.

[45] Total expenditures since leaving Sacapulas, not counting mule hire, for our party up to this point had been less than \$15.00. This was carried in denominations of not over 25 cents.

[46] A. Recinos, *op. cit.*, p. 176.

[47] April 2nd to 11th, 1934, inclusive. (One day spent in Huehuetenango.)

BASIC PRINCIPLES OF THE NEW MECHANICS

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THE proposition that *any moving material particle occupies in any given moment of time a definite position in space, and that these positions form a continuous line known as trajectory* was always considered as self-evident, and formed the fundamental basis for the mechanical description of the motion of material bodies. The distance between two locations of a given object at different times, divided by the corresponding time-interval, was leading to the definition of its *velocity,* and on these two notions of location and velocity, all classical mechanics was built. It probably never even occurred to any physicist or philosopher that these most fundamental notions used in the description of the outside world can be to any extent incorrect, and it was customary to consider them as given "a priori" (whatever this expression might mean).

However, the application of classical mechanics based on this simple kinematic notion, to the study of the motion of the minute particles, such as electrons, taking place within the miniature atomic systems, was gradually leading to the conclusion that something must be wrong with this old and renowned system. It was also becoming clear that the failure of classical mechanics to describe properly the processes of intra-atomic motion could not be avoided by some simple changes of its basic equations and that it was actually its fundamental principles which were failing within the atoms. The simple kinematic notions of location, velocity and trajectory of motion, constructed by us on the basis of everyday observations, turned out to be *too rough* when applied to the extremely small particles which we have to handle in atomic physics. But if these general notions are no good at all for the intra-atomic world, they also could not be absolutely correct in the case of motion of larger bodies. Thus we are being led to the conclusion that *the principles underlying the classical mechanics must be considered only as some very good approximations to the "real thing,"* approximations which badly fail as soon as we turn to the systems more delicate than those for which they were originally intended.

THE IDEA OF MINIMAL ACTION IN MODERN PHYSICS

The essentially new element which was brought into physics by the study of atomic phenomena consists in *the existence of a certain minimum for all possible interactions between different physical systems.* It was first indicated by Max Planck in 1900 that no consistent theory of radiation is possible unless we accept that the radiative energy is emitted by material bodies only in a form of certain portions or quanta of energy. The amount of energy contained in each of these radiative-quanta (or the light-quanta) is proportional to the emission-frequency and can be written in the form:

$$E_{radiation} = h\nu = \frac{hc}{\lambda} \qquad (1)$$

where h is the famous constant of Planck ($= 6{,}547 \times 10^{-27}$ erg. sec.), ν is the frequency and λ the wave-length.

It was later shown by Albert Einstein that the phenomenon of photo effect, in which the kinetic energy of emitted photo-electrons depends only on the frequency but not on the intensity of the il-

lumination, gives an excellent proof of the validity of Planck's hypothesis extended to the radiation as it propagates freely through the space. In fact, the classical physics would lead us to the conclusion that the less intensive light must also give less energy to the electrons knocked out from material bodies. But, if the radiative energy is always concentrated in certain elementary portions, depending only on the frequency, the decrease of the intensity of light will cause only the decrease of the total number of photo-electrons, but not of the energy of each one of them.

Still later the experiments of Arthur H. Compton have also shown that, in its interaction with the free electrons, the light behaves as if it was formed of a number of separate energy-packages amounting to $h\nu$ erg each.

Parallel with this progress of the quantum point of view in the problems of radiation, there was developing a very analogous situation in the case of purely mechanical systems. It was first indicated by Niels Bohr in 1913 that the stability of electronic motion within an atom and the discreteness of atomic spectra could be understood only on the basis of a hypothesis that *the mechanical energy of atoms could accept only a certain discrete set of numerical values.* This hypothesis was strongly supported by the beautiful experiments of J. Franck and P. Hertz, who have shown that the bombardment with the fast electrons can produce any sensible changes in the bombarded atoms, then and only then when the energy of electrons reaches certain well-defined values. The formula defining the quantum of energy of mechanical systems is more complicated than in the case of radiation, and depends on the particular structure of the system in question. One can say, however, that the order of magnitude of these mechanical energy-portions is very well represented by the expression.

$$E_{\text{mechanical}} \sim \frac{h^2}{ml^2} \qquad (2)$$

where m is the mass of the moving particle and l the geometrical dimensions of the system. We see that whereas in the case of radiation the quantum of energy decreases with the increasing wavelength of emitted light (formula 1), the quantum of mechanical energy decreases with the square of the dimensions of the system.

It must be specially stated here that *the both above given expressions for the minimum amount of radiative and mechanical energies do not represent the results of some special theory, but can be considered as derived directly from the experimental evidence of modern atomic physics.* This notion of minimum energy, leading to a certain lower limit for all possible physical interactions, represents something absolutely new and unknown to classical physics. Therefore, revising the principles of the classical system in its application to atomic world, we must, as it was first done by Werner Heisenberg, question the consistency of the old kinematic notions with the new ideas concerning the lower limits of any physical interaction.

Criticism of the Classical Notion of a Trajectory

Let us see first of all how the fundamental notion of the trajectory of a moving particle is being formed in the old mechanics. The analysis of such a kind can hardly be found in any book on classical mechanics for the apparent reason that, before the quantum crisis arose, the notion of the trajectory was always considered as self-evident and nobody really cared to go deeper into its definition. We would normally say that we form this notion by observing the motions of the particle in question and that we can directly *see* the line along which our particle is moving. But seeing involves the illumination of the moving object, and

we must be careful not to disturb the motion by the light falling on it. We know in fact that there is such a thing as the light-pressure, and the light reflected from the surface of the object will cause certain minute perturbations of its motion. Of course, in all practical cases the light-pressure is negligibly small. However, we are not discussing here the practical estimate of the trajectory but its validity as the absolute and fundamental notion of mechanics; in such cases nothing can be neglected and even the smallest disturbances must be carefully taken into account.

In classical physics, however, we can safely eliminate the disturbing effect of the illumination by reducing the intensity of light as much as we need to. In fact, the classical physics sets no limits for the amount of light-energy which can be reflected by a material body, and any amount of this energy, however small, is considered to be theoretically measurable by physical apparatus. We can use, for example, the following schematic

FIG. 1. AN IMAGINARY ARRANGEMENT DESIGNED TO ILLUSTRATE HEISENBERG'S CRITICISM OF THE CLASSICAL NOTION OF TRAJECTORY. THE MOTION OF A MATERIAL PARTICLE AS SEEN AT TEN SUCCESSIVE ILLUMINATIONS.

procedure: Suppose we want "*to see*" the trajectory of a small stone thrown originally in a horizontal direction and falling down under the forces of gravity. To reduce as much as possible the disturbing effect of light-pressure, we can decide to illuminate the chamber in which the stone is moving only at those moments at which the observations of its location are actually being made.

Thus we can flash the lamp, let us say, ten times during the fall, observing ten different locations. The intensity of the lamp and the period of illumination should be chosen sufficiently small to make the total disturbance due to the light-pressure as small as we want it to be; as we have seen, the classical physics set no theoretical limits in this direction. But ten points is not the trajectory, and to arrive at the notion of a continuous line as used in classical mechanics, we must be able to increase the number of the observed points without any limit. This can be also done, in principle, without increasing the distortion of the motion, by decreasing the brightness of the lamp parallel with the increasing number of separate flashes. Thus, going to the limit of infinitely large number of observations, and infinitely small intensity of illumination, we can finally arrive, theoretically, at the strict notion of a mathematical line representing the trajectory of motion.

There is one more point to be taken care of. It is well known from the principles of optics that the image formed by light reflected from a small body can never be made smaller than the wave-length of the light used. Thus, if we really want to get a mathematical line (provided we study the motion of a "material point") and not a more or less broad indefinite band, we have to use very short wave-lengths. Here again no hindrances are set forth by classical physics, as it recognizes the existence of arbitrarily short waves of arbitrarily

low intensities. All we have to do is to decrease the amplitude of light waves, increasing at the same time their frequency, and we shall have our line-trajectory "directly seen"!

All this analysis might seem very silly to the reader, and it probably would be silly if the classical physics were correct. But, as it is not difficult to notice, this "empirical construction of the trajectory-notion" contains the requirements which, being natural for classical theory, are not possible in the light of our new knowledge on quantum-phenomena. We have seen in fact that the light energy can exist only in form of certain definite portions, or light-quanta, and that the higher the frequency, the larger is the energy contained in each such portion. Thus the minimum amount of light which can be reflected from the moving object to make it visible is one quantum of energy, and the kick which it gives to the object can not be reduced any more. Of course, decreasing the frequency of light we can decrease the energy-content of the light-quanta; this will lead, however, to the increasing wave-length and consequently to the increasing "thickness of the trajectory" which we want to avoid. We see that, quantum-laws being valid, the exact notion of the trajectory can not be formed as the limiting case of optical observation.

The second method which we could attempt is the mechanical one. We can, for example, prepare a large number of miniature mechanical "shock-registering" apparatus, and spread them in the space through which the object in question will be moving. Those of the apparatus which have registered a shock will give us the idea of the track of the moving object, and increasing their number simultaneously decreasing their size we might arrive again at the limiting notion of the trajectory as a mathematical line. Here, however, just as in the optical method, the laws of quantum-physics prohibit us from arriving at the finite result. According to the Bohr's quantum conditions (formula 2), the energy required by such mechanical apparatus to "register the shock" will increase with their decreasing dimensions. Very small apparatus of this type will either not register the shock at all or take too much energy from the moving object. Thus we see that the mechanical method leads to the same result as the above-described optical one, and, as far as the quantum laws hold, there is no way to come to the logical definition of a trajectory as a mathematical line. The best we can do is to represent the track of motion by a more or less spread-out band, the thickness of which is defined by the value of the quantum constant "h." It must be clear, of course, that, because of the small numerical value of this constant, these "basic thicknesses" of mechanical trajectories are negligibly small in all practical cases, and become of importance only for such minute particles of electrons moving within miniature atomic system. For atomic electrons, however, the "thickness of trajectory" becomes comparable with the "diameter of the whole orbit," so that no further application of classical notions is any more possible.

The author emphasizes here a great danger that, after struggling through the last few pages, the reader will not quite lose his adherence to the classical notion of the trajectory. "I quite agree" —he would say—"that the observations might disturb the motion and even make the measurement of the trajectory quite impossible. But, if we do not light the lamp, and do not put the shock-registers on the way of the particle, there will be nothing to disturb its motion. Will it not then move along a strict mathematical line?"

Those who put such a question have not evidently understood the principal purpose of the above analysis. We have

not been discussing the possibility of observing the trajectory under the assumption that it is there. On the contrary, we tried to verify the necessity of the introduction of such a notion as a trajectory by means of primary observations of the outside world. And, as far as such a notion can not be strictly constructed, there is no sense of using it, only because Galileo Galilei and Isaac Newton introduced it, not knowing about the existence of the lower limits of physical interactions!

In a dark chamber with no "shock-registers" on its way, the particle will be subject to the same kind of indefiniteness in its motion, simply because such are the laws of nature which we only tried to exhibit by the observations described above. Probably the most striking demonstration of this fact can be seen in the processes of spontaneous or artificial radioactive transformations where a charged particle penetrates into or escapes from the interior of an atomic nucleus, "passing" through the regions of the space in which its potential energy is *larger* than its total available kinetic energy. It is clear that *from the point of view of classical theory no continuous trajectory, observable or not, can pass through this potential barrier surrounding the nucleus,* and yet the experiment teaches us that *the penetration still takes place.* We have here a typical example of the complete failure of the notion of the trajectory in the description of physical phenomena.

Uncertainty Relations of Position and Velocity

The fall of the notion of "the trajectory of motion" results also in serious changes of our views concerning the position and velocity of a material particle and leads to the conclusion that these two fundamental characteristics of motion can not be estimated simultaneously. In fact, if we could know exactly the position and the velocity of a particle at any given moment, we could calculate its prospective positions in the future and form in this way the notion of the trajectory. The analysis of the physical methods by which one could arrive at a simultaneous knowledge of the position and velocity of a moving particle brought W. Heisenberg to the result that any exact estimate of position will disturb the "knowledge" of velocity and *vice versa.* These considerations, very analogous to the above discussion of the "trajectory-observations," lead to the fundamental relation between the "uncertainty" of the position and that of the velocity of a moving particle. If we denote by Δx the "uncertainty" of position and by Δv the corresponding "uncertainty" of velocity, the "*uncertainty-relation*" can be written in the form:

$$\Delta x \cdot \Delta v \geq \frac{h}{m} \qquad (3)$$

where m is the mass of the particle in question. The heavier is the particle, the better its positions, velocities and trajectories could be described by the methods of classical mechanics. It must be noticed here once more that the word "uncertainty" does not pertain only to the results of our measurements, but rather indicates the fundamental indefiniteness of motion as described by the laws of the new mechanics.

Uncertainty Relations of Time and Energy

We want to discuss here in some more detail the uncertainty relation between the time and energy, the relation which is generally less known than those between the positions and velocities. This relation can be written in the form:

$$\Delta E \times \Delta t \geq h \qquad (4)$$

and its importance was particularly emphasized by N. Bohr. It indicates that we can not know the exact amount of energy, together with the exact time when this energy was delivered. Macro-

scopically speaking, we would say that the bill for the electric energy used at a quite definite date must be necessarily uncertain by a negligibly small fraction of a cent.

The validity of this uncertainty relation can be demonstrated by an imaginary apparatus designed for the purpose of the exact measurements of both energy and time in contradiction to the above relation.[1] The "apparatus" consists essentially of a closed box inlaid with the ideal mirrors, and filled with a certain amount of radiant energy. Inside of the box is located an alarm clock connected with a photographic shutter in one of the walls. The clock (which is, of course, also ideal) can be set on a definite moment of time at which the shutter must be opened for one short moment, letting out some part of the radiation. Charging the box with the radiation and setting the alarm clock, we can close it entirely, separating its inside from the outer world. We have enough time now to measure its weight and, using the relativistic relation between the mass and energy, find out *exactly* the total amount of radiative energy in its interior. Another weight-estimate, executed after the date on which the alarm clock is set, gives us the final mass, and the difference corresponds to *the exact amount of energy radiated at the exact moment when the shutter was opened.* The fact that the box is completely closed, having the alarm clock inside, seemingly guarantees the absence of any outside perturbations produced by the process of weighting on the rate of the clock. It seems, at the first sight, that this "imaginary apparatus" would permit the exact

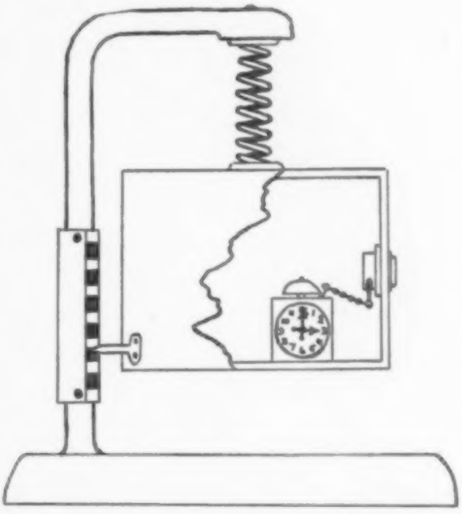

FIG. 2. AN IMAGINARY ARRANGEMENT DESIGNED TO ANALYZE THE POSSIBILITY OF THE SIMULTANEOUS MEASUREMENT OF THE ENERGY AND TIME. THIS TOY-MODEL WAS USED BY PROFESSOR N. BOHR IN HIS LECTURES ON THE INTERPRETATION OF THE UNCERTAINTY RELATIONS.

estimate of energy at the exactly given time, and thus would contradict the uncertainty relations of the quantum-theory.

However, it was indicated by N. Bohr that one can not measure the weight of the box without permitting it to move in the vertical direction in the gravitational field of the earth. In fact, whether we use an ordinary balance or spring scales (as in Fig. 2), the change of the mass to be measured will cause the vertical shift of the box together with the alarm clock fastened in its inside. But, according to Einstein's theory of relativity, any clock changing its position in the gravitational field would necessarily also change its rate. The resulting uncertainty of the time at which the shutter was opened is calculated to be exactly the same as it would follow from the fundamental relation given by formula (4).

Thus we see that, because of the relativistic effects which necessarily come in in any estimate of the mass in the gravi-

[1] The "apparatus" was proposed by A. Einstein at the Solvay Congress on Physics in 1930 as a possible contradiction to the Bohr-Heisenberg interpretation of the new mechanics. The explanation (given in text) as to why such apparatus does not represent any contradiction, and, on the contrary, supports the uncertainty relation, was given by N. Bohr at the same congress.

tational field, the uncertainty relations between the energy and time remain in force also in this case.

Uncertainty Relations for Large Bodies

As it was mentioned above, the quantum-mechanical uncertainty relations become of importance only for the particles of extremely small mass, and play no essential role in the everyday life.[2] It is therefore very interesting to see if there are any examples in which the deviations between the classical and quantum-mechanics could become large enough already for the bodies of normal size. Such examples can be really found, and one of them[3] will be discussed here. Let us take an ideally spherical elastic ball, say, one inch in diameter, and fix it rigidly on the surface of the table. If we place now another ball of the same size a few feet above the first one, and let it drop freely (Fig. 3), the classical mechanics would predict that the ball will jump up and down, all the time hitting the fixed ball exactly on the top.

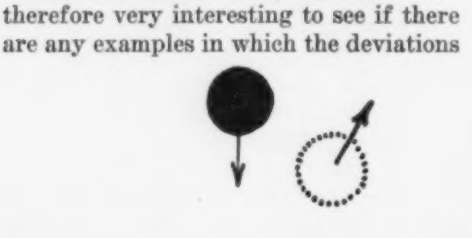

FIG. 3. IN THE NEW MECHANICS A STEEL-BALL DROPPED FROM A POINT DIRECTLY ABOVE ANOTHER RESTING BALL WILL JUMP ASIDE AFTER ONLY FEW BOUNCINGS. CLASSICAL MECHANICS WOULD NATURALY NEVER COME TO SUCH CONCLUSION.

According to the quantum-theory, however, the fundamental uncertainty of the location and velocity of the moving ball will cause the spreading-out of its trajectory. This will lead to uncentral hits and, after several bouncings, the ball will jump aside and fall on the table. The calculations show that, even in spite of the extremely small value of the quantum constant, the ball in the above example will be not able to do more than a dozen successive bouncings. Of course it is hardly necessary to mention that even the best steel-balls used in modern ball-bearings are by far not sufficiently spherical and homogeneous for such experiments, so that the proposed experiment can not be used for the actual demonstration. But it indicates that even in ordinary life the uncertainty relations of the new mechanics could play a certain role.

[2] The question as to how the "everyday life" will look if the quantum-laws would hold also for larger bodies could be found in the author's popular book, "Mr. Tompkins in Wonderland" (Macmillan Publishing Company, New York. 1940).

[3] Communicated to the author by Professor D. M. Dennison.

NIGHT OVER EUROPE

BY DR. RAYMOND B. FOSDICK
PRESIDENT, ROCKEFELLER FOUNDATION

THE mounting catastrophe in Europe and its effect on universities and laboratories in every country there—whether involved in the war or not—have necessitated modifications in the work of the Rockefeller Foundation. When the war broke out on the first of September, 1939, the foundation had 110 running appropriations in Europe, distributed in 22 different countries, and involving a total sum in excess of $4,000,000. A substantial part of these appropriations was for research in various scientific fields. Nearly $2,000,000 of the total was for work in Great Britain; approximately $750,000 was allocated to Switzerland; $330,000 each to France and Sweden; and the balance in smaller amounts ranging down to $3,500 in Finland.

In a number of instances work supported by these appropriations is being continued on a level that has been but little affected by the war. For example, Heilbron's research in organic chemistry, to which the foundation is contributing at Imperial College, London, is still going forward. Niels Bohr's work in biophysics at Copenhagen and Svedberg's studies with the supercentrifuge at Uppsala are also only indirectly disturbed. The Tavistock Clinic in London where the foundation is financing research in psychosomatic medicine, is proceeding, thus far at least, without serious interruption. Similarly, work in the general field of neurology, under grants from the foundation, is being carried on at the Universities of Brussels, Leiden, Lund, Oslo and Oxford.

Moreover, in spite of many unfortunate exceptions, there seems to be at least some effort in influential circles in Europe to insulate important scientific research work from the shock of war and to allow the laboratory men to continue with their tasks. In this respect, Europe is perhaps profiting by the tragic example of the last war when men like Henry G.-J. Moseley, the physicist; von Prowazek, the parasitologist; S. B. McLaren, the mathematician; Karl Schwarzschild, the astronomer, and a great host of fresh new leaders in every field of science were killed at the front. Of the 240 enlisted students of the École Normale Supérieure in Paris, an institution which supplies the French universities with professors, 120 were killed. Among the graduates of this school, 560 who were already professors in the universities were mobilized; 119 were killed. Of the students resident at the École Centrale des Arts et Manufactures, the most important engineering school in France, 179 were killed, together with 362 of the graduates.

This memory is still fresh in scientific circles in England, France and elsewhere, and efforts are being made, with the help of governments, to prevent in this war, as far as possible, the recurrence of such ghastly sacrifice.

But an attempt to keep scientific workers at their tasks, laudable as its motive is, meets but a small portion of the problem. At best it can salvage for the future only those whose promise is already indicated. Nowhere is there occult imagination to detect in a humble patent examiner a future Einstein, or to see in a tanner's son a Louis Pasteur. Darwin at 20 showed no particular promise in his studies; but he had courage and spirit and would have made excellent material for the front-line trenches. No human precaution can protect a nation

from the sacrifices which war levies upon future talent—the undiscovered scientists, the gifted minds, the intellectual and spiritual leaders upon whom each generation must build the hope and promise of the generation to come. The mortgage which war places upon the economic resources of a country is as nothing compared with the mortgage levied upon its future intellectual and cultural life.

In the war that is now being carried on in Europe the sacrifices and the processes of disintegration have already begun. We can see now something of the extent of the disaster. The University of Warsaw has ceased to exist. According to reliable reports, the entire Polish faculty of the University of Cracow is in a concentration camp. The Polish members of the faculty of the University of Vilna have been dismissed. Scarcely a year ago, the Moors, entrenched in the ruined University of Madrid, used the books from the university library as defenses in their rifle pits. The University of Prague has been shut by the German government. The University of Strasbourg has been torn from its site and planted in Clermont-Ferrand. For reasons of economy and because their students are in military service, more than half the universities of Germany are closed. The institutions comprising the University of London have been uprooted and scattered over a wide area in southern England. The 20,000 student population of the University of Paris has shrunk to 5,000. In all countries, whether combatant or non-combatant, the undiscriminating necessities of military mobilization have decimated faculties and student bodies alike. In many instances the ablest men on a faculty are being drafted for various types of war work. In other instances, on both sides of the fighting lines, laboratories hitherto devoted to the extension of knowledge, both in medicine and in the natural sciences, are being geared into the war machine. As a prominent governmental official on the continent recently said, "Science can now have but one object: to help win the war."

Perhaps the most frightening aspect of modern war is the intellectual blackout which it creates. One does not have to subscribe to H. G. Well's grim prophecy that "mankind, which began in a cave and behind a windbreak, will end in the disease-soaked ruins of a slum"; but certainly the night in Europe can not be long continued without the sacrifice of cultural values on so vast a scale that the chance of an enlightened and gracious life, not alone for this generation in Europe, but for the children and grandchildren of this generation, will be irretrievably lost.

Divided We Fall

One occasionally hears the statement that the trend of intellectual leadership is westward across the Atlantic. In proof of the assertion specific fields are mentioned, such as neurosurgery, astronomy, dentistry and perhaps orthopedics, in which America has won preeminent standing. But this argument overlooks the many fields in which leadership, certainly until the war began, was still in Europe and the many others in which genius and stimulation are as potent on one side of the ocean as on the other. In physiology, for example, it would be difficult to determine whether the leadership lies in Europe or in the United States. The same is true of anatomy and pathology. In fields like pharmacology, tropical medicine, ophthalmology, legal medicine, social medicine and dermatology—to mention only a few—leadership is unquestionably still in Europe, or was in 1939. In mathematics, the English are indisputably preeminent in analytic number theory; the Russians are making important contributions in topology and probability, the

French in algebra. America can not match the group of European scientists in the important fields of enzyme chemistry and the organic chemistry of natural products. Nowhere else in the world can one duplicate or even approach the coordinated and cooperating Scandinavian group which is focusing so many precise techniques of chemistry and physics on problems of biology.

If one is tempted to question the vitality of science in Europe, it is interesting to note that the most dramatic scientific development of the year 1939 originated there, i.e., the splitting of the atom of the heavy element uranium and its transmutation into barium and other light elements. This realization of the old dream of the alchemists was based upon results obtained in 1934 by the Italian physicist Fermi; but the disintegration products of uranium were first directly observed in 1939 by Hahn and Strassmann of Berlin.

America needs to be humble about this question of intellectual leadership. In spite of the anxiety and insecurity abroad during these recent years, of the six Nobel prizes awarded in science in 1939, five went to Europe and one to the United States. In countless ways we are dependent upon Europe for stimulation and leadership in relation to many segments of our intellectual and cultural activity.

If because of war exhaustion or chaos the universities and laboratories of Europe should be forced to suspend their fundamental activities for even half a decade, the consequences to the intellectual life of America would be immediate and disastrous. For scientific growth is almost invariably the result of cross-fertilization between laboratories and groups in widely separated parts of the world. Only rarely does one man or one group of men recite with clear, loud tones a whole important chapter, or even a whole important paragraph, in the epic of science. Much more often the start comes from some isolated and perhaps timid voice, making an inspired suggestion, raising a stimulating question. This first whisper echoes about the world of science, the reverberation from each laboratory purifying and strengthening the message, until presently the voice of science is decisive and authoritative. Thus, in the case of the breakdown of uranium during the past year, the early tentative questionings came from Rome; they were caught up at Berlin, were eagerly heard at Paris and Copenhagen, and then spanned the Atlantic and were seized upon here so enthusiastically that literally within hours, rather than within days, the critical experiments had been checked and extended at Columbia University, at the Carnegie Institution of Washington and in Lawrence's laboratory at the University of California.

Similarly, the amazing development and application of sulfanilamide—that beneficent gift to mankind—has been the result of a collaboration in which flags and boundary lines have been nonexistent. The first hint of it was discovered in Germany, oddly enough in connection with the commercial dye industry, and the drug was given the name prontosil. With this hint as a basis, in 1935 a German scientist—Dr. Gerhard Domagk—published the results of his experiments with mice under carefully controlled laboratory conditions, showing the extraordinary effect of prontosil on streptococcus. The Pasteur Institute in Paris then picked the matter up, and subjecting prontosil to organic analysis discovered that its activity was localized in one distinctive part of its molecular structure. This potent factor in prontosil, separated from the rest of the molecule, is what we now know as sulfanilamide. At this point Queen Charlotte's Hospital in London, with a grant from the Rockefeller Foundation,

tried the drug on women suffering from streptococcal infection associated with puerperal or childbirth fever, immediately reducing the death rate from such infections by 25 per cent. The Johns Hopkins School of Medicine was the next institution to carry forward the experiments, and in the last three years research on this drug has been developed, with brilliant results, in laboratories and hospitals on both sides of the Atlantic.

Achievement in science, more often than not, is the result of the sustained thinking of many minds in many countries driving toward a common goal. The creative spirit of man can not successfully be localized or nationalized. Ideas are starved when they are fenced in behind frontiers. The fundamental unity of modern civilization is the unity of its intellectual life, and that life can not without disaster be broken up into separate parts. If, as a result of the present cataclysm on the other side of the Atlantic, Europe freezes into an Arctic night, we shall not easily keep the fires lit in the universities and laboratories of America.

A SCIENTIFIC APPROACH TO RELIGION

By the Reverend JOHN S. O'CONOR, S.J.

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A STRANGE trend has emerged in recent years among certain writers on scientific subjects, a trend which is directly away from the goal towards which these writers profess to be aiming. Despite the fact that in general our concepts of natural phenomena are becoming more well defined and our knowledge of the world in which we live is growing continuously more extensive, as well as more definite, nevertheless in semi-popular books on scientific subjects, as well as in the more reputable journals, remarks dealing with any aspect of religion have for the most part been characterized by a lack of clear thinking and a vagueness which would lead one to conclude that the authors had chosen the reciprocal of the "h" of quantum mechanics as the limit of their indeterminacy rather than that minute magnitude itself.

In view of such articles as the recent one by Dr. K. T. Compton on "Religion in a Scientific Era," as well as a previous one by the late W. M. Davis on "The Faith of Reverent Science," both of which appeared in the SCIENTIFIC MONTHLY (January, 1940, and May, 1934), it seems appropriate to ask the question: Why do men of science refuse to approach the subject of religion from a scientific viewpoint?

Are they *assuming* without reason that faith and science are irreconcilable so that any attempt at reconciliation is doomed to failure from the start? Do they *postulate* without further examination that dogmatic religion is necessarily and essentially incompatible with the scientific method? Do they *deny a priori* that authority as a source of true knowledge must be abandoned *in principle?* If they do then they are no longer acting in the role of scientists but are subscribing to propositions the truth or falsity of which they show no evidence of having investigated.

The purpose of this article is to indicate not only that the scientific method of approach to religion is possible but as a matter of fact can be carried through to very definite and, perhaps to some, illuminating conclusions.

In order to avoid points of controversy inevitably connected with sectarianism this discussion will be conducted

along only very general lines, will be kept for the most part in the hypothetical mode, and the treatment will emphasize the form and method of approach rather than the matter or content of the various religious questions involved.

We should begin of course by defining religion in a manner acceptable to all participants in the discussion. However, even the etymological or nominal definition of religion is open to two interpretations, one which is based on the notion of a bond (from the Latin *religare,* to bind) and another which stems from the Latin derivative *relegere* or *religere,* to treat carefully, to ponder or meditate.

To get a least common denominator for all religions is a task beyond the scope of this consideration, yet an unbiased study of the history of religions and of comparative religion sustains a position which maintains that, despite the presence of admixtures such as ancestor worship and accretions of magic and witchcraft, the notion of a supernatural or supreme being is contained at least implicitly in practically all religions. So that on the first interpretation of the nominal definition of religion the idea of God is introduced historically as the term of the bond between man and a higher being, while on the second interpretation this supreme being appears, on the same historical basis, as the object of man's meditations.

The position taken here is one which is entirely unassailable on anthropological grounds. It starts with a *proof* of the existence of God as the First and Unproduced Cause of the universe. His supreme dominion by reason of this creation and conservation follows logically. It is the recognition by man, through his intellect, of this supreme dominion and the regulation of his life, through the power of his free will, in conformity with the manifest will of God that constitutes the true essence of religion.

To establish this position let me offer some hypothetical propositions, proposing them as the mathematicians propose their postulate systems, and then examine their consistency. If the existence of an intelligent being as the First Cause of the universe can be established by *rational scientific inference* from observed facts, if no other rational explanation of the produced intelligent beings existing in the world to-day has ever been found, then is not the only truly scientific position the one which accepts the existence of such a First Cause which we call God? The objection that such reasoning is based on unjustifiable extrapolation from the seen to the unseen is certainly not valid. Those who maintain it are driven back into a positivism which would throw out most of the conclusions of modern physics. How much of what we call scientific knowledge is based on observations of the senses *alone?* As has been said so often we have never seen and never will see a free electron. We do, however, see its *effects* in cloud chamber and on the recorder of a tube counter, and from the sensible evidence we *infer* (by the principle of sufficient reason) the existence of a cause of the track or pulse, which we name the electron. The knowledge of the existence of a First Cause is reached in the same manner, using the data derived from the senses and reasoning by the same laws of logic without which no scientific conclusion whatsoever could be reached.

In such an article as this there is not space for a detailed delineation of the cosmological argument for the existence of God, but I am absolutely convinced that any one who would give the same consideration to that proof, as outlined for example in William Brosnan's "God and Reason" (Fordham University Press) pp. 62 *et seq.,* as he would give to a line of argumentation found in the *Physical Review* or the *Proceedings of the Royal Society* would be forced to

admit that the cogency of this argument for the existence of God far outstrips that which is found in the reasoning which Chadwick uses to prove the existence of the neutron, which to-day is accepted as certain as any conclusion in the physical sciences.

Now for a second hypothesis: Granted the existence of an intelligent First Cause does it not follow that such a being must possess knowledge, and as the First Cause of all intelligent beings capable of intercommunication, He must also have the power of communicating His knowledge to other individuals? Is there any conceivable reason why such a being could not be the legitimate source of new knowledge for mankind? Any reason offered for the rejection of such testimony would also exclude all human testimony, and make a continuation of the recent rapid advances in science practically impossible. If we accepted in science only those conclusions which we have drawn from facts which we ourselves have observed how far would we get in any investigation? All mathematical, chemical and physical tables could be thrown away since on such a basis we would have to refuse to accept the values contained therein merely on the word of those who have determined them. Every time we wished to perform an experiment involving some additional constant we would have personally to determine its value.

On the contrary we are, as a matter of fact, accepting on faith many hundreds of items in both our daily routine as well as in our original researches. We are permitting authority to become a legitimate source of useful information for us.

It is futile to say that if we so wished we could verify all conclusions we so accept. The fact is that we do not do so, and in many cases could not, even if we wanted to do so. To take but one example, could we set the universe in reverse and reobserve the path of the light rays in the sun's gravitational field during the eclipses of 1919 and 1922? While it is true that the art of photography has given an objectivity to much physical data not enjoyed in the earlier days of science, even here we must accept the authority of the photographer inasmuch as we admit his requisite knowledge and mastery of the technique as well as his honesty in not retouching the film.

The conclusion is inescapable. If we admit the existence of a personal God we must also admit the possibility of revelation by Him to mankind. This admission is not to be made on the basis of some blind impulse which we dare not attempt to explain, but on the basis of judgments similar to those which we make about every-day matters—scientific and otherwise. Assent to the possibility of revelation is therefore reasonable and rational, and such is the *de jure* statement of the case.

As to the *de facto* situation; here again we have a problem which most scientists refuse to face in a scientific manner. Does God exist? Has he revealed Himself to us in any more direct manner than by His manifestations in nature? The students of Catholic *scientific* theology are convinced that the answers to these questions must be given in the affirmative, and they base their position on what they consider incontrovertible physical evidence—evidence that has been for a period not far short of 2,000 years, and still is acceptable to a large group of scholars.

Instead of investigating this evidence all but a few scientists are content with dismissing the entire problem by quoting the mistakes of a few misguided individuals, and they then refuse to pursue the matter further.

If all the articles on science were taken up with such topics as the mistaken notions of Newton concerning the

corpuscular nature of light or the persistent refusal of Lord Kelvin to accept, in the face of convincing evidence, Rutherford's theory of radioactive disintegration, the literature of physics would indeed be in a sorry state. And while such a situation does not exist regarding the topics which are the proper subject-matter for most scientific discussion, yet when questions of religion arise the attitude seems to change so as to preclude concentration on all but a few extreme and to-day scientifically untenable religious positions.

Because the electronic charge has been found to have a value different, by an amount greater than the admitted limits of experimental error, from the universally accepted value of 4.770×10^{-10} abs. e.s.u. we do not therefore completely discard the concept of the electron. Neither should we consider all religion "outmoded" because of the fanatical theological interpretation of a particular bizarre sect. Individual mistakes in arithmetic do not destroy the foundations of mathematics. Nor do the personal errors of whole schools of thought make all reasoning processes invalid. It is human to err as the ghosts of phlogiston and elastic solid ether theory can testify, but because of such errors science has not concluded that the continuation of the search for truth is futile.

Let me therefore present a further question which should again be answered from a scientific viewpoint: Granted the existence of God and the possibility of revelation and given the fact that certain groups of propositions are claimed by their defenders to be revealed truths, are not these claims entitled to the same attention and examination as is accorded to any other scientifically acceptable hypothesis?

The establishment of the tenets of true Christianity regarding revealed truths begins with a consideration of the authenticity and genuineness of scriptural writings as well as the historicity of the events recounted therein. From the valid testimony of these writings considered as historical documents we conclude legitimately not only to the existence of the person of Jesus Christ and the doctrines which He taught but also to the occurrence of certain special manifestations connected with His life and death. These special manifestations called miracles (such as resurrection from the dead) never have and never will receive an adequate *natural* explanation. They constitute mighty motives of credibility and irrefragable external proof that what is claimed to be Divine revelation is actually so. Nor can they be dismissed merely by the use of depreciatory adjectives, as has been done by the late W. M. Davis referred to above. No truly scientific refutation of the existence of miracles has ever been written because it would require a proof either of the non-existence of God or else put the author in one of two extremely uncomfortable and unscientific positions of having to either deny all and any form of physical law or, admitting such, he would then have to prove that any change in the admitted law would be forever and absolutely impossible.

Let me turn now from argument to illustration and propose an analogy which should add strength to the appeal for a scientific approach to religion. The scientific method is one which accepts facts and attempts to fit them into a theory or system. Agreement between fact and theory may establish or confirm the latter, but in all cases it at least renders the theory under test acceptable for further consideration. The facts of history pertaining to the teachings of Christ constitute a body of data. These have been moulded (under the guidance of Christ Himself) into a system, in such a way as to constitute an organism which displays the proper

functioning of the relations between theory and fact. Not only does this organization give a satisfactory interpretation of the facts on the basis of the theory which it represents, but this synthesis has been for 1,900 years and still is a workable system for millions of individuals the world over. So that to the pragmatic question, uppermost in the minds of so many to-day, revealed religion also gives a positive and favorable answer.

A further question must still be proposed: Does the system of revealed religion under consideration contravene any of the known facts of science?

The answer to this question will be given in the form of a challenge which may be stated as follows: No doctrine or dogma essential to Christian revelation and defined as such by either a general council of the Church of Rome or by any *ex cathedra* declaration of any pontiff of that same church has ever been found in contradiction to the certainly known facts of science.

We are of course assuming that the "conscientious objector" to the above proposition will investigate the meaning of Papal infallibility and *ex cathedra* definition before dragging out the already threadbare instance of the condemnation of Galileo.

Let us now turn to some of the views of Dr. Compton as expressed in the article referred to previously. In his summary Dr. Compton says, "Its (science's) whole tendency is to emphasize the fundamentally spiritual character of religion as representing the highest ideals of mankind *as opposed to theological rules, doctrines, theories, etc.*" (Italics mine.) Elsewhere in the article Dr. Compton speaks of "the dynamic character" of religion and "the need of a variety of religious denominations which emphasize different aspects of . . . the spiritual life." Regarding the changes in and diversity of religions, a distinction is necessary which may take its point of departure from the words of Dr. Millikan quoted in the same article. "I believe," says Millikan, "that essential and not dogmatic religion is one of the world's supremest needs." In this quotation a complete but gratuitous opposition is set up between a religion and its dogmas; the implication is that dogma is not essential to religion. But it is merely implication and not proof. If a religion holds nothing certain, nothing true, what is it worth as a religion—is it worthy of the name? It is of course true that religion, culture and knowledge itself may differ accidentally in different countries and in different periods of development, but it is obviously impossible for the same religion to teach essentially different doctrines at different times as it is absurd to claim that two religions which are in such essential opposition can both be true.

When we use a coordinate system to solve a problem, the important physical quantities in the problem are independent of our choice of a reference system. They are what are called invariants. The essential doctrines so frequently referred to with contempt as "dogmas" are the invariants of true religion. They remain the same throughout all transformations in space and time. Without them the adequate solution of the problem of the universe will never be obtained.

BOOKS ON SCIENCE FOR LAYMEN

EVOLUTION OF THE PHYSICAL UNIVERSE[1]

WHEN Milton decided to write an epic poem he chose a much more heroic subject than those of any of his predecessors who sang of "arms and a man" or other adventures of ordinary mortals. In "Paradise Lost" Milton sang of the rebellion of Satan and his horrid crew, "who durst defy th' Omnipotent to arms." For nearly three hundred years imaginations have been stirred by the superlative events he described.

Dr. Gamow has written on a subject that in the field of the physical sciences makes the ultimate demands upon the imagination and credulity. His work is not based upon theology and mythology, but upon carefully reasoned theories derived from observations. He writes with authority, for he himself has contributed important parts to the great theoretical structure that has been erected.

Naturally Dr. Gamow could not start with the birth of our sun and other suns, for the past as well as the future must be inferred from the present. He first raises the question of the origin of the sun's heat, a subject that has been puzzling scientists for eighty years since it was first realized that heat has the property of quantity, the same as mass. He passes in review the inadequate contraction theory and develops the recent theories of the liberation of energy through the transmutation of the elements, especially hydrogen, including the carbon-nitrogen cycle.

Inevitably theories of the origin of the heat of the sun apply in general to the heat of the stars. For the first time a fairly coherent theory of the evolution of the stars has been worked out. It is interesting that the lives of these great bodies are determined by the properties of atomic and subatomic particles of which they are composed, somewhat as the lives of the largest animals depend upon the microscopic and submicroscopic organisms to which they are hosts. Following the stars backward, Dr. Gamow finds a time when they were greatly expanded and cooler and were much closer together. In fact, he places their birth at about two billion years ago. He follows them as they contract and increase in temperature, for a time mostly as a consequence of their contraction, and later as a consequence of the transformation of elements. According to this theory, our sun is getting hotter, though very slowly, and will eventually radiate so much energy that life on the earth will be destroyed. Eventually, however, it will pass a climax, the climax depending upon its mass, and then decline in size and brilliance. Then "after another long period, our sun will turn into a giant lump of lifeless matter covered with eternal ice and surrounded by a system of frozen but still faithful planets."

This book is excellently and interestingly written, with many a whimsical turn that will prove that the most exacting scientists away from their specialties are quite as human as other folk. The drawings by which Dr. Gamow has illustrated many of his descriptions and arguments are equally entertaining and instructive. Intelligent readers who find pleasure in reflecting on the great problems of the origin and destiny of the universe, of which this earth is a trivial part, will greatly enjoy this book and will be brought up to date by reading it. Has the final answer to the origin, evolution and destiny of the universe at last been found? Some advance has been made toward the answer to this problem, but there probably will be no *final* answer.

F. R. M.

[1] *The Birth and Death of the Sun.* By George Gamow. Illustrated. xi + 238 pp. $3.00. 1940. The Viking Press.

THE SOCIAL SCIENCE ROLE OF GENETICS[1]

THE intimacy of the relations between the social and biological sciences is fortunately increasing rapidly. Any effort to clarify their mutual interdependence is of value not only to the sciences themselves but to humanity as a whole. The biologist frequently requires to be reminded of the significant human, social and economic implications of his work. The social scientist, working with that most complex and baffling of organisms, human society, obtains much useful data and even more valuable techniques and disciplines from the biologist. When sociology finally divorces sterile philosophy to wed science, the offspring may prove to be the salvation of mankind. To forget that we are biological is to be no longer logical.

Biology, medicine and sociology are inseparable. The first deals with the fundamentals of life, the second with man as an individual and the last with the interrelations of man. A new text-book by Professor Burlingame, of Stanford University, has as its primary objective the correlation of these three fields of study by the common denominator of heredity. Each living organism carries the blessings and curses of its ancestry: it is what it is because heredity and environment jointly control development. The principal aims, as stated in the preface, include a brief introduction to the biology of reproduction, the fundamentals of genetics and a discussion of how and where this knowledge is applicable to social problems in the broader sense. These objectives are attained.

Though the author claims that this is a text-book rather than a comprehensive treatise, the book is so splendidly organized, the facts are so well selected and the theoretical discussion so thoroughly thought out that the volume makes fascinating reading independently of any "course." How rare are the texts of which such may be said! The style is excellent: clear, concise and free from ambiguity. The discussions of the rôle of heredity in the theories and practices of government and mass movements of mankind (war and/or migration) are largely speculative. As such they are provocative of thought by revealing a fresh perspective. Chapter XIX, "Heredity and Medical Problems," and XX, "Heredity and Insanity," are the weak links in this otherwise excellent chain. Here the weakness lies in the lack of clinical knowledge. Those portions dealing with the socio-economic aspects of medical practice are stimulating reading.

The illustrations are well chosen and aid greatly in clarifying the mechanics of heredity to non-biologists. Typography, paper and binding are all of a high order. The book is highly recommended to all those thinkers concerned with the bio-social future of mankind: physicians, biologists, social scientists, philanthropists and statesmen. The more our students, who are the future citizens and voters, understand the implications suggested by this book the more secure and progressive is the future of democracy.

EDWARD J. STIEGLITZ

[1] *Heredity and Social Problems.* By L. L. Burlingame. Illustrated. xi + 369 pp. Price $3.50. 1940. McGraw-Hill Book Company.

TRY IT YOURSELF[1]

IN twenty brief chapters, Dr. Freeman takes his readers over a considerable part of physics—from "The Stuff the World is Made of" to "Light and Sight." This survey is neither heavy nor trivial. It has neither the ponderosity of the academic specialist nor the frothiness of the science-magician. With restrained enthusiasm, the author introduces a large number of important principles of physical science by means of illustrations that

[1] *Invitation to Experiment.* By Ira M. Freeman. 238 pp., 114 illustrations. $2.50. 1940. E. P. Dutton and Company.

are within the mental horizon of nearly every person. The familiar is skilfully made to reveal the general.

One of the attractive features of the book is the numerous illustrations, both reproductions of photographs and line drawings. The photographs are appropriate and the line drawings are excellent, often superior. Some of the photographs show great commercial applications of the principles under discussion, such as an airplane ready for testing in a full-scale wind tunnel and the huge stabilizing gyroscope installed on an ocean liner. The drawings often illustrate experiments that any one can make. In fact, they justify the title of the book, "Invitation to Experiment." They are not only illustrative but are very interesting.

Perhaps Dr. Freeman acquired an interesting and lucid style by writing scripts for broadcasts. At any rate, the style of his new book is excellent. He has proved that fundamental science can be made clear and interesting without burdening the reader with a large number of unfamiliar words. Although his sentences are simple and direct they are so varied in length and structure and tone that they are never monotonous.

As Dr. Freeman says in his Introduction, he addresses himself to the general public. After remarking that a considerable amount of interpretation of science has been published during the past few years, he says: "Much of this literature has tended to dwell unduly on the latest and most imposing achievements of pure and applied science—the whipped cream of the subject—supplying only sketchily if at all an exposition of the fundamental concepts on which the imagination-stirring fruits of modern scientific achievements are based. . . . Certainly—with a little explanation—a lump of iron is fully as remarkable as a filterable virus or the latest plastic, and gravitation is no less wonderful than cosmic rays or vitamins."

F. R. M.

AN ACCOUNT OF THE MARINE WORLD[1]

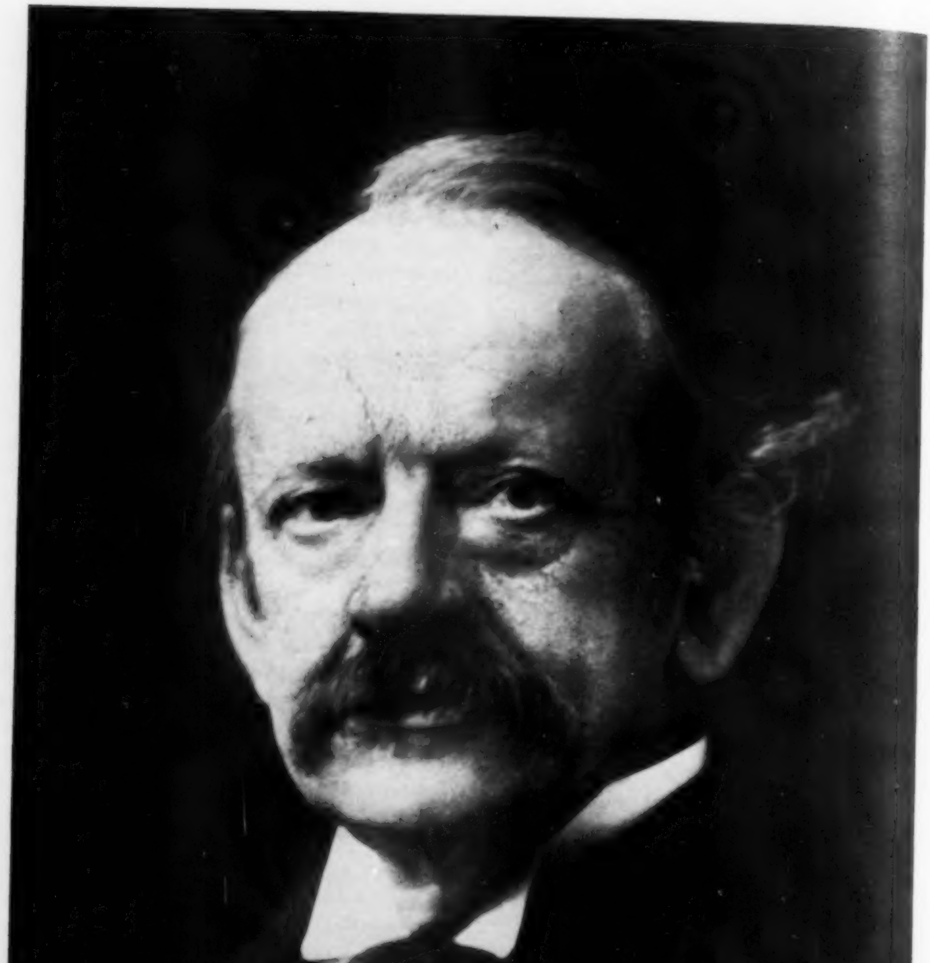
In "The World under the Sea" the author covers admirably the varied and interesting science of oceanography. Five chapters devoted to physical oceanography give the high lights of our present knowledge on such subjects as submarine geology, earthquakes, volcanoes, temperatures, chemistry, light penetration, tides and currents, including methods and devices used for deep-sea exploration. Diagrams show the profiles of the various oceans and reveal, for example, the immense uniform expanse of the ocean floor in parts of the Pacific in contrast to the deeps and plateaus of the Atlantic.

Thirteen chapters treat of life within the sea, from the shores' edge to the oceans' abyss. This is discussed broadly and well. An account is given of the remarkable abundance and variety of life on the continental shelf and of the mysterious populations in the great depths where total darkness prevails. In order are described the plant life—bacteria, diatoms, seaweeds, the animal life, ranging from the lowly forms such as foraminifera, sponges, jellyfish, corals, worms, to the highest invertebrates—crustaceans, molluscs, starfishes, etc., and, finally, to the vertebrates—fishes, reptiles and mammals. Birds are given a passing mention, for, as the author states, they might well occupy a volume by themselves.

The book is well illustrated, concludes with a brief discussion of economic factors and has a good index. The reader is sure to find this treatise most interesting and instructive.

William C. Schroeder

[1] *The World under the Sea.* By B. Webster Smith. Illustrated. xix + 230 pp. 1940. D. Appleton-Century Company.



SIR JOSEPH JOHN THOMSON

THE PROGRESS OF SCIENCE

THE WORK OF SIR JOSEPH JOHN THOMSON

THE father of the new era of science has joined his ancestors in the great family of the immortals whose race began with Newton.

Rich as has been the life of science since Thomson discovered the electron, its span has been but short in years. But short as it has been, it has seemed even shorter; for new domains have opened up with such speed that there has been no rest to count the passage of time, and even to-day one is apt to think of the beloved J. J. as a young man, and to be almost startled to recall that he died (August 30, 1940) at the ripe age of 83.

Thomson was symbolic in part of the old school of physics and in part of the new. Like Newton, Kelvin, Maxwell and Rayleigh, with Faraday standing as an exception, he was thoroughly trained in the technique of, and constructive in, mathematical physics, and this great power stood always in readiness to serve the needs of interpretation of his experimental researches. Unlike these great predecessors, however, whose interests ramified over all fields of natural philosophy, he symbolized that era of specialization which has evolved more or less as a necessary consequence of the ever-increasing complexity in all fields of physics.

It was in 1884 that Thomson became Cavendish professor of physics at an age —28 years—so unusual for such distinction, particularly in those days, as to bring forth from a well-known college tutor an utterance to the effect that things had come to a pretty pass in the university when mere boys were made professors. He was precipitated into this realm of responsibility from a school of physics which seemed to have attained the goal of all that was ever likely to be possible, a school in which many were busy in polishing up the work of their predecessors by adding a decimal point here and there. In this school a certain pedantic spirit of caution had evolved, a spirit which feared lest science should become contaminated in the slightest degree by speculation. The ideal was to confine attention as far as possible to the experiments themselves, and drag from them such light in the matter of understanding and correlation as they were capable of revealing, by a more or less empirical dissection with strict adherence to use of the surgical instruments provided by the mechanisms of mathematical analysis. Suggestions of inner structures to facilitate the reasoning were viewed with suspicion. One was allowed to speak of a *current of electricity* as a convenience of language, but woe unto him who implied that he was thinking of anything moving along the wire. Even Maxwell, the father of mathematical electrodynamics, hesitated to speak of *particles of electricity;* and when for convenience in discussing electrolysis he is constrained to speak of a molecule of electricity, he says that the phrase is out of harmony with the rest of his treatise. One was permitted to speak of atoms and molecules more or less in whispers, but the discipline imposed upon one's thoughts is symbolized by the great Kelvin's complaint made, in later years, against the new ideas of atomic structure and disintegration, a complaint which maintained that the very word "atom" implied that the entity was indivisible. The atom was given a name—a name considered safe to protect it from heresy —and it was expected to live up to its name.

There was an exception to the unseen things which were forbidden. Physics, feeling the need of something in which to transmit light waves, had come to admit an aether, and classical dynamics

occupied such a respectable place as the vassal of all the mathematicians since Newton, that it was regarded as a highly proper agency to operate the aether. Physics had a merry time for many years trying to make an aether which could be worked by the dynamics or a dynamics which would work the aether. The desire for a substantial aether, and a conventional one, is illustrated by such remarks as that of the eminent contemporary of J. J. Thomson, Arthur Schuster, who, as late as 1904, writes: "The study of physics must be based on a knowledge of mechanics, and the problem of light will only be solved when we have discovered the mechanical properties of the aether." Writing, in another place, of Maxwell's equation, he remarks: "The fact that this evasive school of philosophy has received some countenance from the writings of Heinrich Hertz renders it all the more necessary that it should be treated seriously and resisted strenuously."

Thomson himself was sensitive to the call of the new for contact with the old, and following Faraday, but aided by a more comprehensive mathematical knowledge, he spent much effort in seeking to interpret Maxwell's mathematical framework in terms of the seemingly more concrete properties of "tubes of force." His earlier writings on "Applications of Dynamics to Physics and Chemistry" and his "Treatise on the Motion of Vortex Rings" show close contact with the type of investigations of his mathematical predecessors, but even in the early eighties we find him interested in the properties of moving electrical charges, regarded as concrete entities. After his election to the Cavendish professorship, his interests centered rapidly upon that field of conduction of electricity in gases in which he and his many eminent students did so much to write that new chapter in the history of science which gives immortality to his name.

Like most radicals in physics, Thomson became quite conservative in his own radicalism, and did not look with any great favor upon the birth of even the Bohr-Sommerfeld theory. In spite of this, in seeking ways of correlating nature within the frame of the philosophy of classical electrodynamics, he was bold in speculation, even beyond the courage of those who viewed a complete break with the past with equanimity.

Thomson's "Recollections and Reflections" contains an interesting side light upon his attitude towards creative thinking. He writes: "There is no better way of getting a good grasp of your subject, or one more likely to start more ideas for research, than teaching it or lecturing about it, especially if your hearers know very little about it, and it is all to the good if they are rather stupid. You have then to keep looking at your subject from different angles until you find the one which gives the simplest outline, and this may give you new views about it and lead to further investigations. I believe, too, that new ideas come more freely if the mind does not dwell too long on one subject without interruption, but when the thread of one's thoughts is broken from time to time. It is, I think, a general experience that new ideas about a subject generally come when one is not thinking about it at the time, though one must have thought about it a good deal before."

Thomson symbolizes, perhaps more than any other physicist, the creator of a "school" of physics. When one thinks of him, it seems impossible to separate him from this school. Beloved by his many illustrious students, he seems rather as an elder brother among them, a brother in a family which will forever remain illustrious in the annals of science.

W. F. G. Swann,
Director

Bartol Research Foundation of the Franklin Institute

LEONARDO DA VINCI EXHIBITION AT THE NEW YORK MUSEUM OF SCIENCE AND INDUSTRY

THE scientific investigations and achievements of Leonardo da Vinci are graphically demonstrated at the New York Museum of Science and Industry in an extensive exhibit which will be on view for the rest of the year. Dr. Frank B. Jewett, president of the Museum, recently paid the following tribute to da Vinci:

For a long time the greatness of Leonardo da Vinci rested on a few works of art which survived the accidents of time. Centuries rolled by, almost to the threshold of our own day, before the world began to stir with an awareness of the immense debt it owed him as a scientist and inventor. Even to-day, indeed, few realize the extent to which the industrial civilization of America traces its spiritual beginnings to his amazing genius.

Leonardo was born in Vinci, Tuscany, in 1452 and died at Colux, France, in 1519. Beside his few major works of art, which include the *Mona Lisa* and the *Last Supper*, the record of his achievements consists of some seven thousand sheets covered with drawings and notes. These pages show that all his life Leonardo was obsessed with two aims: to perfect his powers of artistic expression, and to find the order in nature which would enable man to harness its forces in his service. Nothing that came within the range of his faculties was alien to him. He looked on all creation, and he challenged its mystery with the prodigious power of his mind.

Neither Leonardo's studies, nor his inventions, proceeded in any organized or systematic fashion. Instead, following the course dictated by the chaotic events of his life and times, he ap-

PARTIAL VIEW OF THE EXHIBITION OF LEONARDO DA VINCI'S WORK

AT LOWER LEFT IS ONE OF THE FAMOUS FLORENTINE'S DESIGNS FOR A WATER WHEEL. IN THE FOREGROUND IS A MODEL OF ONE OF HIS MULTIPLE-STRAND PULLEYS. ALONG THE STAIRWAY ARE REPRODUCTIONS OF SKETCHES FROM HIS NOTEBOOKS, WHILE ABOVE IN THE BACKGROUND IS A GLIMPSE OF THE MILITARY MACHINES SECTION.

LEONARDO DA VINCI—A SELF-PORTRAIT

plied himself now to one, now to another science. In his last years, he did attempt to edit and set his manuscripts in order, but before he was able to complete this task, death put an end to his gigantic endeavors.

"Science," wrote da Vinci, on one of those seven thousand pages left as his heritage to humanity, "is knowledge of the things that are possible, present and past; prescience, knowledge of the things which may come to pass." Thus, in a reflection jotted down at random, did one of the greatest geniuses the world has ever known, define for himself the limitless territory he had set himself to explore."

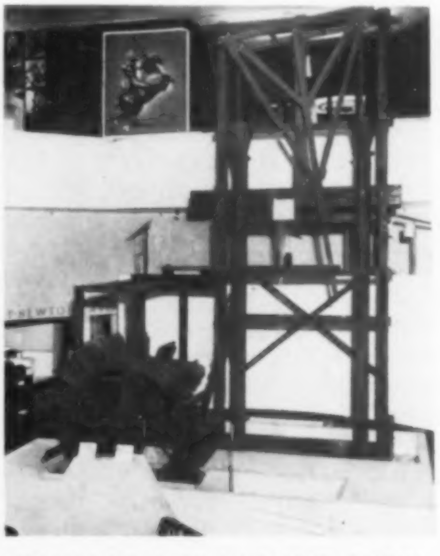
The exhibition, part of a comprehensive display of Italian scientific inventions held in Milan during the summer of 1939, consists of approximately 200 working models, built from original sketches, diagrams and notes. The models were carefully reconstructed by Italian technicians and artisans in the spirit of Leonardo's own time, even the raw materials employed in their making being as close as possible to that available to workers in the fourteenth and fifteenth centuries. Many of the models, according to the scholars and scientific experts who collaborated in the work of reconstruction, can stand comparison with the most modern techniques and inventions, and not a few of them resemble certain of those to be seen to-day in any up-to-date machine shop or factory.

The various exhibits in the collection show that Leonardo da Vinci's many-sided scientific curiosity led him into practically every field of human interest. They deal with anatomy and botany, with astronomy and geology, with mathematics, architecture, aviation, hydraulics, military engineering and with other fields. There are ten models concerned with flight in the exhibition, including models of flying machines, a parachute; an "aerial screw" that appears to some observers to have been based on the principle of the helicopter and is said to be the "ancestor of all modern airplane propellers;" and a number of instruments intended to gauge wind velocity and humidity.

Seven models have to do with city planning, some of which—dealing with the problem of traffic regulation—bear

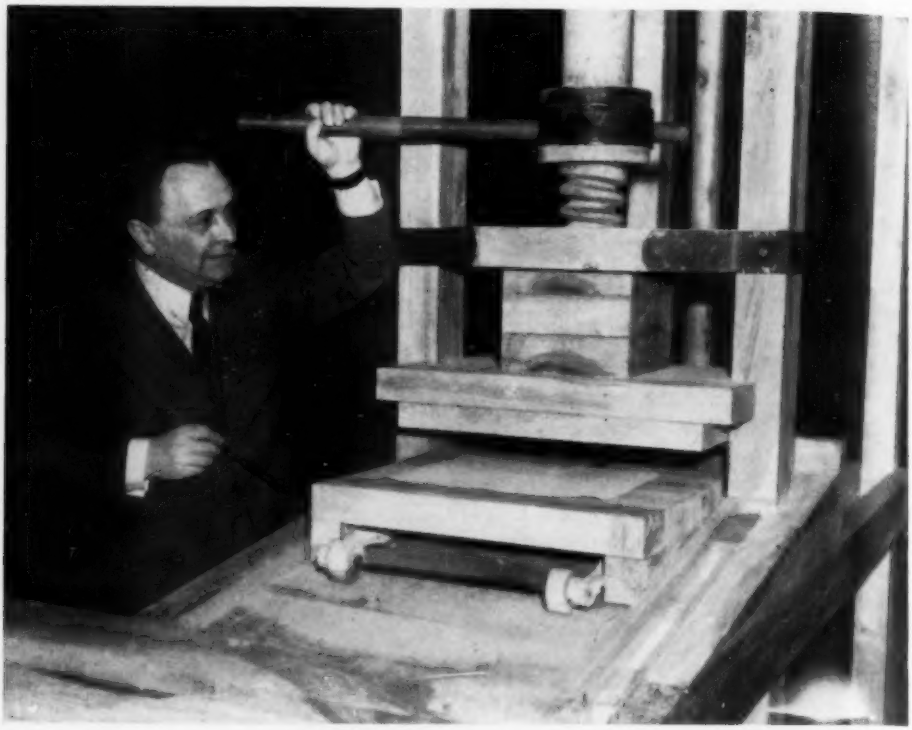
A PAGE FROM DA VINCI'S NOTEBOOK

SHOWING SOME OF HIS DESIGNS FOR MILITARY MACHINES. BELOW IS SEEN A DEVICE FOR HURLING PROJECTILES OF VARIOUS TYPES, MADE TO OPERATE IN THE MANNER OF A CROSS-BOW.



SCALE MODEL OF A "WATER LIFT"

DESIGNED BY LEONARDO DA VINCI FOR USE IN CONNECTION WITH THE BUILDING OF A CANAL FROM FLORENCE TO THE SEA. THIS WORKING MODEL IS ONE FIFTH THE SIZE OF THE ORIGINAL.



WORKING MODEL OF DA VINCI'S CONCEPTION OF A MOVABLE PRESS

IT WAS DESIGNED BY DA VINCI NEARLY 100 YEARS BEFORE THE ONE INVENTED BY JOHN GUTENBERG IN GERMANY, WHO IS GENERALLY CREDITED WITH CREATING THE FIRST MOVABLE PRESS.

a marked resemblance to designs offered by modern architects as a solution of the problems of congestion which beset the large cities of to-day. The largest of the models in this group, that of the "Ideal City," is close to twelve feet long and some ten and a half feet wide. In addition, there are 22 plaster models of miscellaneous subjects in the architectural display.

Nineteen models are concerned with various aspects of hydraulics, showing Leonardo's ideas relating to the building of canals, dams, sea locks, basins, bridges and the like. One of them shows an ingenious gate in a lock. When the capstan in the background is turned, the gate slowly drops into a pocket, allowing the water to pass into the canal. This method of raising or lowering boats around natural obstructions is, of course, much the same as that in use to-day.

Among the miscellaneous mechanical inventions are a sheet metal machine or "rolling mill"; a variable speed drive, forerunner of our modern automobile transmission; a model embodying the principle of the modern ball bearing, for elimination of friction in moving parts; an automatic roaster, the idea for which da Vinci conceived while watching an inn keeper laboriously turning a roasting pig on a spit; two printing press models; a screw-threading machine; a device which forecasts the modern steam shovel; a steam engine; an automatic saw, forerunner of the modern buzz saw used in lumber mills; and a number of others. Machines for work in the field of optics, a flying spindle, a paddle wheel ship, a valve action pump and twelve other types of pump, a cloth shearer and an automotive cart equipped with differential gears to transmit power to the rear wheels are

some of the other exhibits of high interest.

Some thirty or more models are related to da Vinci's studies of military and naval operations, made while he was military engineer in the service of Caesar Borgia. They include a design of a fortress containing underground passages, bridges for use in military operations, various types of guns, an armored ship, a double-hulled vessel and apparatus for breaking and piercing the hull of an enemy ship, also a diving apparatus which the great inventor is said to have left incomplete because he feared that "man's wickedness and ferocity" would result in its misuse.

The various models have been set up to show how their originals developed in da Vinci's mind. To this end, an enlarged reproduction of that page from da Vinci's notebooks containing the sketches and diagrams of each machine or device has been placed in the background behind each model. In some instances, numerous drawings are exhibited, presenting various phases of his studies, notably in the section devoted to his work in aeronautics, where a great variety of his notes and sketches dealing with his observations of the flight of birds are shown.

Each of the two main stairways leading to the mezzanine levels of the Museum is lined with drawings which further emphasize the diversity of Leonardo's interests and artistic genius. Here are seen sketches of the heads of madonnas, of animals, of mechanical conceptions, of flowers and plants, hair arrangements, allegorical subjects, mathematical studies, costumes, draperies, caricatures and a host of others. Not infrequently, little drawings of wholly unrelated subjects will appear on the same page, indicating the speed with which many different concerns moved through the master's mind.

Not the least interesting to visitors to the exhibition are the reproductions of notes written in da Vinci's curious right-to-left script, requiring the use of a mirror before the words could be read. Two sentences from his notes have been reproduced on the walls at the foot of each main staircase, faithfully copied in this "mirror writing." One of them reads: "Every action of nature is made along the shortest possible way," and the other, "Oh Lord, thou sellest us all good at the price of labor."

The installation of the exhibition was supervised by Dr. Giorgio Nicodemi, director of the Department of Fine Arts of the Common of Milan and Director of Museums in the Sforza Castle, who came to New York with two technicians. Dr. Nicodemi is one of Italy's outstanding authorities on Leonardo da Vinci, and has written many books on the great Italian scientist and painter. He is a member of the Royal Commission for Publication of Texts on Leonardo da Vinci.

M. C. M.

EIGHTH SUMMER CONFERENCE ON APPLIED SPECTROSCOPY

The eighth annual summer conference on applied spectroscopy was held at the Massachusetts Institute of Technology during July 15 to 17, with 250 biologists, chemists, metallurgists and physicists taking part, as well as a few representatives of other sciences. Thirty papers were delivered during the three all-day sessions, with discussion periods following each paper.

The amazing power of spectroscopic methods to furnish information about matter in almost any state was responsible for the gathering together of representatives of so many sciences in one group. To the astronomer the spectrograph has revealed much about stars and nebulae as units of study. To the archeologist it can contribute information regarding objects fashioned by human hands, as shown in a paper by Dr. Daniel Norman, of the New England Spectrochemical Laboratories, reporting on a spectroscopic comparison of Central American and Asiatic jades. The physicians of the audience were particularly

interested in a discussion of the relative potencies of various Vitamin A materials, as determined spectrographically by Dr. R. L. McFarlan, of the United Drug Company; in an analysis of Saratoga Springs mineral waters by Dr. Lester Strock of the Saratoga Springs Commission; and in a paper on the absorption spectra of hemoglobin derivatives by Dr. David L. Drabkin, of the University of Pennsylvania.

Passing from human to plant health, the program contained much to interest the agriculturist; in particular a comparison of the metal content of the leaves of various varieties of grapes, reported by Dr. B. C. Brunstetter, of the U. S. Department of Agriculture; and studies of the bearing on plant growth of metallic constituents of the soil, as determined with the spectrograph, presented by Dr. L. H. Rogers, of the University of Florida.

Entering the realm of the molecule, there were various papers of interest primarily to chemists, such as the spectroscopic study of thionine solutions presented by Dr. L. F. Epstein of the Massachusetts Institute of Technology, the spectroscopic determination of atmospheric ozone by Dr. Brian O'Brien, of the University of Rochester, and a description of a new spectrophotometric method of measuring fast reactions by Dr. F. Karush, of the Massachusetts Institute of Technology.

The physicist, concerned with atoms and their behavior, was represented by Dr. W. F. Meggers, of the National Bureau of Standards, who discussed the physical basis of spectrographic analysis; by Dr. O. S. Duffendack, of the University of Michigan, who reported on measurements of temperatures in spectroscopic sources; by Dr. M. F. Hasler, of the Applied Research Laboratories of Los Angeles, who discussed a special type of arc for spectrochemical use, and by a number of others. Further papers were concerned primarily with metallurgical analysis, and at least a dozen involved discussions of new methods and apparatus for improving the general spectroscopic analysis of materials.

This annual conference, started in 1933 as a temporary measure to forward the development of applied spectroscopy, has filled such a need that all seats at recent conferences have been reserved in advance. At this eighth conference it was decided that a permanent organization should be formed, to be known as the Society of Applied Spectroscopy. Officers were elected for the ensuing year as follows: *President*, Dr. G. R. Harrison, Massachusetts Institute of Technology; *Vice-President*, Dr. W. F. Meggers, National Bureau of Standards; *Secretary*, Dr. R. A. Wolfe, University of Michigan; *Treasurer*, Dr. T. M. Hess, Dow Chemical Company.

One of the first items of business of the new society was consideration of the desirability of founding a quarterly *Journal of Applied Spectroscopy*, to take the place of the *Proceedings* of the Spectroscopy Conference, hitherto published annually.

GEORGE R. HARRISON

NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

THE officers of the National Research Council, in response to suggestions from many of the constituent societies of the council, have recently initiated a move for the development of a national roster of scientific personnel. After a series of conferences, it appeared that the roster should be extended to include not only scientists, but other specialized Americans as well. In this connection, the Social Science Research Council, the American Council of Learned Societies and the American Council on Education joined in a request to the Federal Government that such a roster be developed.

In compliance with this request, a new federal project has been established which is called the National Roster of Scientific and Specialized Personnel. This roster is administered jointly by

the Civil Service Commission and the National Resources Planning Board. Its executive officer is James C. O'Brien, of the Civil Service Commission, and its director, Leonard Carmichael, president of Tufts College.

The development of the roster, which is now in active production in Washington, has involved the construction of an elaborate questionnaire, to be sent to all scientists and specialized workers in the country. Accompanying this questionnaire, as sent to each individual, is a check list of special proficiencies in his own field. For example, a group of cooperating physicists has developed a list of items of specialized proficiencies in that science which will allow each physicist to designate the field or fields in which he has greatest capacity. The information received from this check list and questionnaire will then be coded in connection with the already existing federal occupational codes. Incidentally, this procedure will extend these codes to the specialized proficiencies of scientists. After the material received from each individual has been properly coded, it will be entered upon punch cards and thus made analytically available for the special demands of governmental and other agencies as they appear in connection with emergency and other placement demands. It is difficult to ascertain the total number of individuals who will be included in this continuing census, but it is almost certain that the figure will reach at least the half-billion mark.

LEONARD CARMICHAEL,
Director

ECLIPSE EXPEDITION OF THE NATIONAL GEOGRAPHIC SOCIETY AND THE NATIONAL BUREAU OF STANDARDS

To observe the total solar eclipse of October 1, the National Geographic Society and the National Bureau of Standards are sending a joint expedition to

MAP SHOWING PATH OF THE TOTAL ECLIPSE OF THE SUN
THE OBSERVATIONS OF THE EXPEDITION WILL BE MADE NEAR THE VILLAGE OF PATOS 200 MILES INLAND FROM THE PORT OF RECIFE (PERNAMBUCO).

eastern Brazil.[1] The party of six specialists which sailed from New York on August 24 for Recife (Pernambuco), Brazil, consists of Dr. Irvine C. Gardner, chief of the Optical Instruments Section of the Bureau, leader of the expedition; Dr. E. O. Hulbert, of the Naval Research Laboratory; Dr. Paul A. McNally, S. J., director of the Observatory of Georgetown College; Dr. Carl C. Kiess, spectroscopist, and Dr. Theodore R. Gilliland, radio research specialist of the National Bureau of Standards; and Richard H. Stewart, staff photographer, National Geographic Society.

From Recife the expedition will go inland nearly 200 miles to the village of Patos, which lies five miles south of the center line of the eclipse. The instruments will be set up directly on that line. The neighborhood selected is considered most favorable for carrying out the full program which the expedition has scheduled. It is on an inland plateau where drought conditions usually prevail during September and early October.

The eclipse conditions themselves are also favorable. The sun will be unusually high (approximately 54°) at the time of totality, and the period of darkness will last for nearly five minutes. To take advantage of these favorable conditions, the National Geographic-Bureau of Standards expedition has designed and built two special spectrographs, each

[1] At least three other expeditions will make observations: One from the Cruft Laboratory of Harvard University, under the direction of Dr. J. A. Pierce, with headquarters in Queenstown, South Africa, will concentrate upon radio problems. Dr. Charles H. Smiley, of Brown University, leads a small party which will study the zodiacal light from Quixeramobin, Brazil. A group from the Amateur Astronomers Association, in New York, led by Charles A. Federer, Jr., will be stationed at Campina Grande, Brazil.

DR. IRVINE C. GARDNER WITH ONE OF THE SPECIALLY BUILT CAMERAS
THE CAMERA WILL TAKE 12 TO 15 PHOTOGRAPHS OF THE CORONA DURING THE MOON'S 5-MINUTE BLACKOUT OF THE SUN. IT WILL BE OPERATED AUTOMATICALLY WITH OTHER CAMERAS AND INSTRUMENTS BY A PROGRAM CLOCK.

capable of photographing a portion of the sun's spectrum 40 inches long. In addition the expedition designed and built especially for the October 1 eclipse two small, compact telescope-type corona cameras. These will be used to photograph the corona, the delicate halo that extends outward around the sun but which can be seen only during total eclipses. Included in the equipment also will be the large telescope camera designed by Dr. Gardner several years ago with which he has photographed solar eclipses on National Geographic Society expeditions in Russia and on Canton Island in mid-Pacific.

Another important group of equipment, housed in an automobile trailer for ease of transportation, will be used during the eclipse to measure changes in the all-important radio reflecting layers of the upper atmosphere, caused when the eclipse briefly shuts off the sunlight. Other apparatus will include miscellaneous cameras, instrument mountings, clocks, motors and batteries. In all, the expedition will take to Brazil some 15,000 pounds of equipment.

The program to be followed by the expedition will include a complete motion picture record in color of the eclipse from the appearance of the first nick in the sun's disk until the moon has completely passed across its face; photographs of the "flash spectrum" of the sun at the two instants when this phenomenon is visible (just before the beginning and just after the end of totality); repeated photographs of the spectra of the corona during the five minutes of totality; special large photographs of the corona, both in black-and-white and in color, with varying exposures; records of the polarization of the coronal light; the radio reflecting layer measurements; studies of sky brightness, sky radiation, sky spectra and temperature and density changes in the atmosphere during totality. In addition, it is possible that precise observations will be made of the times of apparent contact of the edges of the moon and sun—these in an effort to learn why the moon is usually one or two seconds earlier or later than the computed time for its meetings with the sun.

THE "PROGRAM CLOCK"

WHICH WILL AUTOMATICALLY CONTROL TWO SPECTROGRAPHS AND THREE CORONA CAMERAS. THE APPARATUS WAS DESIGNED BY DR. IRVINE C. GARDNER, WHO IS HOLDING A FRAME ON WHICH ARE MOUNTED SHARP BLADES TO CUT SLOTS IN THE PAPER WHICH RUNS THROUGH THE MACHINE.

The carrying out of this program will be notable because of the surprising degree of simplicity that has been achieved by careful planning, and because almost all the instruments will be "tied together" by a combined electric and vacuum control system which will make the operation of the numerous units almost completely automatic. As a result, this will be one of the few expeditions in history during which the scientists may themselves observe the eclipse phenomena, free from the necessity of strenuous work operating controls during the brief period of darkness.

The expedition will set up its instruments a considerable period in advance of the eclipse and will run through numerous rehearsals. When the program is worked out in complete detail, a roll of paper, somewhat like a player piano roll, will be punched with necessary holes and slots and will be run through the "pro-

ONE OF THE SPECTROSCOPES FOR PHOTOGRAPHING THE SUN'S SPECTRUM

DR. IRVINE C. GARDNER (LEFT), LEADER OF THE EXPEDITION, AND A TECHNICAL ASSISTANT EXAMINE THE FILM MAGAZINE MECHANISM.

gram clock'' at a definite rate of speed. Through the open spaces electrical contacts will be made which, at the proper instants, will open and close shutters, wind films, and apply suction to hold films in the proper planes. A second electrical device and recorder operated by a chronometer will make a complete record of all the operations that have taken place, measuring exposures, for example, to the fraction of a second. This record will be available for the proper development of the films and for the study of brightness from the photographs.

The spectrographs are of unusual design. They are slitless, using concave gratings and no lenses. Made of a shining aluminum alloy, the two instruments, twins in appearance, when set up will look like light cannons trained at the sun. Their tubes are about 15 feet long and they have a focus of approximately 11 feet. Each will project a spectrum 40 inches long on photographic film in a giant magazine which lies below the barrel. This magazine has ingeniously been mounted ''on the bias.'' This permits the 40-inch image to be recorded diagonally across a 9-inch strip of film, and makes necessary a winding of only 12 inches of film between each exposure. In the two spectrographs the sun's spectrum is divided so that one instrument takes care of the light of wave-lengths between 3,000 and 5,000 Angstrom units, and the other, the light between 5,000 and 10,000 Angstrom units.

The gratings used in the spectrographs

have been prepared with extreme care and produce images of unusual brightness. One with 15,000 lines to the inch was prepared by Robert W. Wood, of the Johns Hopkins University. The other, by Henry G. Gale, of the University of Chicago, has 30,000 lines to the inch.

The radio-measuring equipment will not be connected with the electric control system, but will be operated independently. Whereas the spectrographs and cameras will be pointed directly at the sun, the radio apparatus will send its signals vertically into the darkness aimed at its invisible target of electrified gas molecules—the radio reflecting layers—from 30 to 250 miles overhead. The signals, or some of them, will be reflected back and received and recorded in the trailer.

After the eclipse the expedition will move to Campina Grande, a city of approximately 90,000 inhabitants, to carry on the necessary laboratory work in the development and preparation of the photographic films. The party will sail from Recife on its return voyage to the United States on October 14, and expects to reach New York about October 23.

M. K.

VITAMIN DEFICIENCY AND ABNORMAL BONE GROWTH OF THE CHICK[1]

THE modern intensive methods of poultry production require that chicks be reared indoors, to protect them from unfavorable weather conditions. Until about 1923 all attempts to do this failed, because chicks are very susceptible to rickets, but after McCollum announced the discovery of vitamin D the agricultural colleges soon developed production methods by which chicks could be grown with no exposure to sunlight, in very limited quarters. On the whole the more recent practices were successful, but a new disease soon appeared which was practically unknown before. The leg bones were shortened and thickened and frequently bent or twisted. In more severe cases the tendon of Achilles would slip out of its normal position and fall to one side of the tibia-tarsal joint. This condition was variously designated as slipped-tendon, hock disease, and more recently as perosis. The appearance of this condition was sporadic and unpredictable, and often resulted in heavy financial losses. The condition was aggravated by including in the ration excessive amounts of calcium phosphate and of other calcium compounds, but was not prevented by supplying only minimal amounts of these mineral compounds.

To digress for a moment, the Missouri College of Agriculture began in 1922 a study of the nutritional requirements of the chick, and attempted to rear them on synthetic diets. Since only five vitamins were known at that time, it is needless to say the attempt was not highly successful, and one of the puzzling abnormalities encountered was the leg deformity later designated as perosis. We considered the possibility at the time that this condition was due to a deficiency of one or more mineral elements, though manganese was the only one that received specific attention. Our observations convinced us that under our experimental conditions this disorder was not due to a deficient supply of any inorganic constituent. Recently this same view was expressed by Wiese, Elvehjem and Hart, who observed that perosis is prevented by rice bran, but is not prevented by rice bran that has been heated to a high temperature. This heat treatment should have no effect on the mineral constituents, but might easily destroy an organic component, such as a vitamin.

In 1936 a very important, and to us surprising, advance in the prevention of

[1] The essential data were presented before the Seventh Annual Meeting of the American Institute of Nutrition, in New Orleans, Louisiana, by A. G. Hogan, L. R. Richardson and Homer Patrick.

this disease was announced by Wilgus, Norris and Heuser, of Cornell University, who showed that under their conditions the deformities were almost entirely eliminated by increasing the amount of manganese in the ration. The minimum amount required was approximately 0.005 per cent. of the food supplied.

After the report of Wilgus, Norris and Heuser appeared then, this is the situation as we saw it. We were unable to prevent perosis by supplying 5 times as much manganese as the Cornell group regarded as sufficient. On the other hand, the Cornell group almost entirely eliminated perosis by merely including a minute amount of manganese in the ration. In our view the only explanation of this discrepancy was that two factors are required to prevent perosis. One is manganese, the other is an unrecognized organic factor, a vitamin. Our synthetic diet had contained an abundance of manganese but was deficient in the vitamin, and the ration of natural foodstuffs employed by the Cornell group was deficient in manganese. Additional support for this view is afforded by the observations of the Cornell workers that occasional cases of perosis developed regardless of the amount of manganese supplied. This indicates that their ration was not only markedly deficient in manganese, but was also mildly deficient in the perosis-preventing vitamin.

The next development in this field is the demonstration that perosis is due to a deficiency of a vitamin. It had been our experience through some 15 years that when liver, either fresh or dried, was added to our synthetic diet, the leg deformities were prevented. An extract of liver is also effective, so the problem was to separate it into two fractions, one of which contains the perosis-preventing factor. The second fraction should not prevent perosis, but it must contain the other vitamins necessary to maintain the chick in a reasonably satisfactory nutritional state. A satisfactory method of preparing the fractions mentioned is first to extract dried liver thoroughly with strong alcohol, at 70° C. This fraction contained the perosis-preventing vitamin, along with various others. The liver residue is then extracted with water, at 70–100° C. This water-soluble fraction does not contain the perosis-preventing vitamin, but it does contain others which are required by the chick. This fraction is a constant constituent of the basal diet used to develop perosis. It is our experience thus far that every chick reared on this ration will be affected; the incidence is 100 per cent. In practice the ration is vastly improved for experimental use by adding it to some of the other vitamins, which are now available in pure crystalline form. If the alcohol soluble fraction of the liver extract is also included in this ration the rate of growth is rapid, and no abnormalities develop. According to our hypothesis the protective action of this fraction is due to the presence of a previously unrecognized vitamin, designated for convenience as vitamin B_p.

When a new vitamin is announced we immediately ask what significance may it have, but as yet we have no information on the requirement for this vitamin by other animals. Our first thought is, since it is concerned with the bone development and conformation of the chick, that it may also be concerned with the structural development of other animals and of man himself. At present, though, one can only speculate.

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